ECONOMIC VALUATION OF WETLANDS

A GUIDE FOR POLICY MAKERS AND PLANNERS

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Foreword

This publication contains much helpful information on various economic techniques that are available by which to value wetland areas. The Guide draws out the importance of weighing the advantages to be obtained by development with the damage which that development may do to wetlands.

The Guide is the result of considerable cooperation between scientists and economists, and I hope that it will be carefully studied as its primary purpose is that it should be practical.

Rt Hon the Earl Ferrers, Minister of State for the Environment and Countryside
United Kingdom

1996

Preface

Today, most planning and development decisions are made on economic grounds and, more and more, on the basis of the forces at play in the free-market system. While this new paradigm has its own limitations and dangers, it would be unrealistic to ignore it and to base our quest for the conservation and wise use of wetlands on a completely different set of values. Hence, wetland goods and services must be given a quantitative value if their conservation is to be chosen over alternative uses of the land itself or the water which feeds the wetlands.

For many products, such as fish or timber, there is a world market which allows easy calculation of the worth of the wetland. The value of wetland functions, such as water quality improvement, may be calculated from the cost of building a treatment works to perform the same processes. It is much more difficult, however, to value biodiversity or the aesthetic beauty of wetlands, as the market for such "products" is much more elusive and their economic valuation much more difficult to achieve with traditional methods. Another major hurdle is that developing countries face significant problems in appropriating the global benefits of wetland conservation, such as their biological diversity (Pearce & Moran, 1994). Consequently, new means of appropriation must be developed and added to.

At its meeting in Brisbane, Australia, in March 1996, the Conference of the Parties to the Convention on Wetlands approved a Strategic Plan that recognises the importance and urgency of carrying forward the work in the area of economic valuation of wetlands. According to Operational Objective 2.4 of the Strategic Plan, the Ramsar Convention will promote the economic valuation of wetland benefits and functions through dissemination of valuation methods. This book sets out to provide guidance to policy makers and planners on what the potential is for economic valuation of wetlands and how valuation studies can be undertaken. Since it is not expected that policy makers will undertake the valuation work themselves, guidance on planning a study and outline Terms of Reference for technical consultants are provided as well.

Throughout human history, the term wetlands conjured up for many people a swamp full of slimy creatures, harbouring diseases such as malaria and schistosomiasis. Indeed it is this view of wetlands as wastelands that has led to extensive drainage and conversion of wetlands for intensive agriculture, fish ponds, industrial or residential land or to improve public health. However, in recent years there has been increasing awareness of the fact that natural wetlands provide free of charge many valuable functions (e.g., flood alleviation, groundwater recharge, retention of pollutants), products (e.g., fish, fuelwood, timber, rich sediments used for agriculture in the floodplains, tourist attractions), and attributes (biodiversity, aesthetic beauty, cultural heritage and archaeology).

The trend towards wetland conservation is exemplified by the many countries that have adopted the policy that there should be no further wetland loss or degradation, that wetlands must be used in a sustainable way and research should be undertaken on quantifying wetland values. International mechanisms and institutions, such as the Ramsar Convention on Wetlands, the Convention on Biological Diversity, the UN Commission on Sustainable Development, OECD, IUCN-The World Conservation Union, Wetlands International and WWF are promoting research, analysis and dissemination of information on economic valuation of natural systems, including wetlands. They advise that decision-makers should fully consider the social benefits of natural ecosystems as well as those of the development proposals being considered and that they should make full use of the available techniques for accurately expressing resource benefits in economic terms.

It is important to stress that economic valuation is not a panacea for all decisions, that it represents just one input into the decision-making process, along with important political, social, cultural and other considerations. The goal of this text is to assist planners and decision-makers in increasing the input from economic valuation in order to take the best possible road towards a sustainable future.

Delmar Blasco
Secretary General
Ramsar Convention Bureau

Executive summary

The aim of this book is to provide guidance to policy makers and planners on the potential for economic valuation of wetlands and how such valuation studies should be conducted. Although a number of economic valuation studies of wetlands have been undertaken around the world and economists have developed methodologies for valuing more intangible aspects of the environment, such as amenity or aesthetic factors, no one has synthesised from this literature a common approach to show its overall usefulness to wetland management worldwide. Consequently, this book provides details of the various techniques and examples of wetland valuation studies together with guidance on planning and managing a study and putting the result into a wider decision-making framework.

Wetlands are amongst the Earth's most productive ecosystems. They have been described both as "*the kidneys of the landscape*", because of the functions they perform in the hydrological and chemical cycles, and as "*biological supermarkets*" because of the extensive food webs and rich biodiversity they support. In Chapter 1, the features of the system are grouped into components (soil, water, plants and animals), functions (nutrient cycling and groundwater recharge) and attributes (biological diversity). Historically, many wetlands have been treated as wastelands and drained or otherwise degraded. The Ramsar Convention on Wetlands of International Importance was created to promote the conservation of wetlands and their wise use and management.

Chapter 2 explains the role of valuation in decision-making. Many development decisions are made on economic grounds. By providing a means for measuring and comparing the various benefits of wetlands, economic valuation can be a powerful tool to aid and improve wise use and management of global wetland resources. In the past, wetlands have been undervalued because many of the ecological services, biological resources and amenity values they provide are not bought and sold and hence are difficult to price. Ramsar is promoting new methods of economic valuation to demonstrate that wetlands are valuable and should be conserved and wisely used.

In Chapter 3, an appraisal framework is developed for assessing the net economic benefits of various wetland use options. Stage one of the framework involves determining the overall objective or problem and choosing the correct economic assessment approach from three broad categories, i.e., impact analysis, partial valuation or total valuation. Stage two requires definition of the scope and limits of the analysis and the information required for the chosen assessment approach. Stage three necessitates determining the evaluation techniques and data collection methods required for the economic appraisal including any analysis of distributional impacts.

To guide the policy maker on how to undertake a wetland valuation study, six examples are given in Chapter 4. These are: the Hadejia-Nguru floodplain in northern Nigeria; prairie wetlands in North America; the Norfolk Broads and Scottish flow country in the UK; nitrogen abatement using Swedish wetlands; coastal wetlands in southeastern USA and mangrove conservation in Indonesia. These case studies provide practical demonstrations of the use of various valuation methods in the field, in different types of wetlands, using a range of valuation methods and covering diverse geographical areas. Although their coverage cannot be claimed as exhaustive, several observations emerge from reviewing these studies. First, the importance of integrating ecological and economic approaches is critical, especially when the valuation of ecological functions is the objective. This requires more than complex mathematical techniques, but extends to continual collaboration between economists and ecologists. The studies also demonstrate that valuation should not be conceived of as an end in itself, but needs to be directed towards some policy issue. These issues may range from simply raising awareness of the importance of wetlands to choices among alternatives to meet some stated policy goal, with protecting wetlands representing just one option.

Chapter 5 provides guidance on planning and conducting a study. These include a seven-step guide to undertaking a study. The steps are: choosing the appropriate assessment approach; defining the wetland area; identifying and prioritising components, functions and attributes; relating these components, functions and attributes to use value; identifying and obtaining information required for assessment; quantifying the economic values; and putting the economic values in the appropriate framework (e.g., cost-benefit analysis). Guidance is also given on resources needed and on compiling Terms of Reference for technical consultants using a fictitious example of a floodplain in Africa. In addition, emphasis is placed upon the need to consider other factors (political, social, historical or ecological), which may be considered alongside the economic valuation results when a decision is being made. Finally, an alternative methodology for decision-making is presented where rare species are at risk.

In Chapter 6, recommendations are made for future actions. These highlight the need to: undertake site-specific economic valuation studies; ensure appropriate interdisciplinary collaboration; provide training and institutional capacity building; undertake research on economic valuation theory and practice; and establish networks for the exchange of ideas and experience of applying valuation methods.

After the main text there is a glossary of terms, a list of references and further reading. The appendices contain details of different wetland components, functions and products; a table comparing economic appraisal methods; and a table detailing advantages and disadvantages of valuation techniques used in the economic appraisal of wetlands.

1. Background to the global wetlands management problem

1.1 Definition of wetlands

It is clear, when you are up to your knees in mud in a backwater swamp in Zambia, that it is truly a wetland. But trying to draw experiences together to provide a precise definition of wetlands is fraught with controversy and difficulty, because of the enormous variety of wetland types and the problems of defining their boundaries. For example, how often and for how long does land have to be flooded before it is considered a wetland? The problems are compounded by the fact that many wetlands evolve over time, starting as open water, but infilling with sediment and vegetation eventually to become dry land. Nevertheless, wetlands certainly occupy the transitional zones between permanently wet and generally dry environments – they share characteristics of both environments yet cannot be classified unambiguously as either aquatic or terrestrial. The key is the presence of water for some significant period of time, which changes the soils, the microorganisms and the plant and animal communities, such that the land functions in a different way from either aquatic or dry habitats.

Fortunately, some pragmatic help is at hand. Some 100 countries have adopted a definition by signing the Ramsar Convention on Wetlands of International Importance (see section 1.5). The Convention adopts an extremely broad approach in determining the 'wetlands' which come under its aegis. In the text of the Convention (Article 1.1), wetlands are defined as:

"areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed six metres"

In addition, the Convention (Article 2.1) provides that wetlands:

"may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six metres at low tide lying within the wetlands"

As a result of these provisions, the coverage of the Convention extends to a wide variety of habitat types, including rivers, shallow coastal waters and even coral reefs, but not deep sea.

1.2 Types of wetland

In trying to categorise the wide range of wetlands encompassed by the Ramsar definition, Scott (1989) defined 30 groups of natural wetlands and nine manmade ones. However, for illustrative purposes it is possible to identify five broad wetland systems:

- estuaries – where rivers meet the sea and salinity is intermediate between salt and freshwater (e.g., deltas, mudflats, salt marshes)

- marine – not influenced by river flows (e.g., shorelines and coral reefs)

- riverine – land periodically inundated by river overtopping (e.g., water meadows, flooded forests, oxbow lakes)

- palustrine – where there is more or less permanent water (e.g., papyrus swamp, marshes, fen)

- lacustrine – areas of permanent water with little flow (e.g., ponds, kettle lakes, volcanic crater lakes)

1.3 Importance of wetlands

The importance of wetlands has changed with time. Back in the swampy environments of the Carboniferous Period, some 350 million years ago, wetlands produced and preserved many of the fossil fuels (coal and oil) upon which we depend today. More recently, wetlands along some of major rivers of the world, including the Tigris, Euphrates, Niger, Nile, Indus and Mekong, nurtured the great civilisations of history. These wetlands provided fish, drinking water, pasture land and transport and were part of the cultural history of early people, being a central element of mythology, art and religion.

As scientific understanding of wetlands has increased, more subtle goods and services have become apparent. Wetlands have been described both as "*the kidneys of the landscape*", because of the functions they can perform in the hydrological and chemical cycles, and as "*biological supermarkets"* because of the extensive food webs and rich biodiversity they support (Mitsch & Gosselink, 1993).

Wetlands are among the Earth's most productive ecosystems. The features of the system may be grouped into components, functions and attributes. The **components** of the system are the biotic and non-biotic features which include the soil, water, plants and animals. The interactions between the components express themselves as **functions**, including nutrient cycling and exchange of water between the surface and the groundwater and the surface and the atmosphere. The system also has **attributes**, such as the diversity of species.

Wetland systems directly support millions of people and provide goods and services to the world outside the wetland. People use wetland soils for agriculture, they catch wetland fish to eat, they cut wetland trees for timber and fuelwood and wetland reeds to make mats and to thatch roofs. Direct use may also take the form of recreation, such as bird watching or sailing, or scientific study. For example, peat soils have preserved ancient remains of people and trackways which are of great interest to archaeologists.

Apart from using the wetlands directly, people benefit from wetland functions or services. As flood water flows out over a floodplain wetland, the water is temporarily stored; this reduces the peak river level and delays the time of the peak, which can be a benefit to riparian dwellers downstream. As mangrove wetlands reduce wave energy, they protect coastal communities, and as wetlands recycle nitrogen, they improve water quality downstream. By benefiting in this way, people are making indirect use of the wetland functions. These functions may be performed by engineering schemes such as dams, sea walls or water treatment plants, but such technological solutions are normally more expensive than when performed by wetlands.

Not all wetlands, however, perform all of these hydrological functions to the same extent, if at all. Indeed, some wetlands perform hydrological functions which may be contrary to human needs, such as riparian wetlands which may act as runoff generating areas, thus increasing flood risk downstream. It is therefore crucial to quantify the functions of a wetland before valuing it.

The mere existence of wetlands may be of great significance to some people. Those who have grown up in wetlands, but have moved away to a town, may have placed a high value on the wetland because it is part of their cultural heritage, even though they may never visit the wetland.

Further details of wetland components, functions and attributes are provided in Appendix 1, while Chapter 2 discusses these in an economic valuation context.

1.4 Wetland loss

Wetlands are dynamic systems, continually undergoing natural change due to subsidence, drought, sea-level rise, or infilling with sediment or organic material. Thus, many wetlands are only temporary features of the landscape and will be expected to change and eventually disappear, whilst new wetlands are created elsewhere. Direct and indirect human activity has considerably altered the rate of change of wetlands. To some degree, we have created new artificial wetlands by building reservoirs, canals and flood storage areas. However, the loss of wetlands has far outstripped the gains.

The view that wetlands are *wastelands*, resulting from ignorance or misunderstanding of the value of the goods and services available, has led to their conversion to intensive agricultural, industrial or residential uses. Individual desires of farmers or developers have been supported by government policy and subsidies. In addition to direct action on the land, river engineering schemes have diverted water away from wetlands, as it has been believed that this water is wasted in the wetland or at least has a lower value than its use for rice irrigation upstream. Some organisations still look upon wetlands only in terms of their potential to provide farm land to feed an ever-expanding population, which normally requires alteration of the natural system. Wetlands may also be lost by pollution, waste disposal, mining or groundwater abstraction.

Table 1.1 Wetland loss in Europe (CEC, 1995)

Country	Period	% loss of wetlands
Netherlands	1950-1985	55
France	1900-1993	67
Germany	1950-1985	57
Spain	1948-1990	60
Italy	1938-1984	66
Greece	1920-1991	63

The amount of wetland lost is difficult to quantify, since the total area of wetland in the world is uncertain. There are, however, some figures for individual countries which indicate the scale of the problem. The United States has lost some 87 million hectares (54%) of its original wetlands (Tiner, 1984), primarily to agricultural production. Figures for wetland loss in six European countries are given in Table 1.1 (CEC, 1995), whilst in Portugal some 70% of the Western Algarve has been converted for agriculture and industrial development (Pullan, 1988). The European Union policy is that there should be no further wetland loss or degradation. In the Philippines, some 300,000 hectares (67%) of the country's mangrove resources were lost in the 60 years from 1920 to 1980 (Zamora, 1984).

Table 1.2 Incidence of major threats to wetlands in Asia, Latin America and the Caribbean (WCMC, 1992), expressed as % of sites.

	Asia	Latin America and the Caribbean
Hunting and associated disturbance	32	30.5
Human settlement	27	
Drainage for agriculture	23	19
Disturbance from recreation		11.5
Reclamation for urban and industrial development		10.5
Pollution	20	31
Fishing and associated disturbance	19	10
Commercial logging and forestry	17	10
Wood cutting for domestic use	16	
Catchment degradation, soil erosion, siltation	15	
Conversion to aquaculture ponds or salt pans	11	
Diversion of water	9	
Over-grazing by domestic stock	9	

A wetland does not need to be entirely lost to reduce its value. Gamelsrød (1992) showed that production of shrimps on the Sofala Bank in Mozambique is related to wet season runoff from the Zambezi. With the building of major dams along the river, runoff and hence shrimp numbers have decreased. He calculates that earnings from shrimp fishing could be increased by US$ 10 million per year by correctly releasing water from the Cabora Bassa dam which is not being utilised.

There are now many cases of wetland restoration, where the results of wetland degradation have been recognised. Making artificial releases from dams to re-inundate degraded floodplains is one mechanism (Acreman, 1994), of which there are examples on the rivers Senegal, Kafue (Zambia), Logone (Cameroon) and Phongolo (South Africa) (Acreman & Hollis, 1996). Nevertheless, these are exceptions rather than the rule and predictions suggest that pressure to "develop" wetlands is intensifying, especially in Asia, Africa and Latin America. Thus, there is still a great need for promoting the benefits of wetlands to encourage conservation and sustainable utilisation, through organisations such as IUCN-The World Conservation Union and the Ramsar Convention.

1.5 The role of Ramsar in wetland conservation

The Convention on Wetlands of International Importance especially as Waterfowl Habitat – commonly referred to as the Ramsar Convention from its place of adoption in Iran in 1971 – was the first of the modern global intergovernmental treaties on conservation and wise use of natural resources.

The mission of the Ramsar Convention (Ramsar, 1996) is "***the conservation and wise use of wetlands by national action and international cooperation as a means to achieving sustainable development throughout the world"***.

The Convention provides a framework for international cooperation and was established following concern in the 1960s about the serious decline in populations of waterfowl (mainly ducks). It came into force in 1975 and currently has 100 Contracting Parties, which are obliged to undertake four main activities. These are:

- to designate wetlands for inclusion in the 'List of Wetlands of International Importance' and to maintain their ecological character

- to develop national wetland policies, to include wetland conservation considerations within their national land-use planning, to develop integrated catchment management plans and, in particular, to adopt and apply the guidelines for implementation of the Wise Use Concept, which is the sustainable utilisation of wetlands for the benefit of mankind in a way compatible with the maintenance of the natural properties of the ecosystem

- to promote the conservation of wetlands in their territory through establishment of nature reserves and to promote training in wetland research, management and wardening

- to consult with other Contracting Parties about transfrontier wetlands, shared water systems, shared species and development aid for wetland projects.

In this way the Convention plays an important role in helping to prevent detrimental changes to wetland sites in states that are party to the Convention. Technical support on wetland conservation is provided to the Convention from organisations such as IUCN-The World Conservation Union and Wetlands International (a new body formed from the International Waterfowl and Wetland Research Bureau, the Asian Wetland Bureau and Wetlands for the Americas). Notable successes include:

- prevention of agricultural development of habitat for Spoonbill *Platalea leucorodia* in the Hortobagy Ramsar site, Hungary (1985)

- the Azraq Oasis in Jordan benefited from being placed on the Montreux Record (a list of sites where changes in ecological character have occurred, are occurring or are likely to occur), the consequent study of threats to the wetland, the recommended solutions and resulting funds obtained from the Global Environment Facility (1990)

- rejection of development proposals which would have had a harmful effect on the Swale Estuary Ramsar site in the UK (1992)

- rejection of plans to build an intensive piggery in the catchment of Lake Cundare and closure of a refuse tip adjacent to Lake Beeac in Victoria, Australia (1993)

The Ramsar Convention is thus vitally important in the conservation of the world's wetlands.

2. Why valuation?

To understand why economic valuation may be important to wetland management and policy, it is necessary first to review the role of valuation in decisions that concern the use of environmental resources generally and wetlands specifically. In this chapter we suggest that a major reason for excessive depletion and conversion of wetland resources is often the failure to account adequately for their non-market environmental values in development decisions. By providing a means for measuring and comparing the various benefits of wetlands, economic valuation can be a powerful tool to aid and improve wise use and management of global wetland resources.

2.1 The role of economic valuation in decision-making

We can define *economic valuation* as the attempt to assign quantitative values to the goods and services provided by environmental resources, whether or not market prices are available to assist us. However, such a definition goes only part way. We must be more specific about what economists mean by the term *value*. The economic value of any good or service is generally measured in terms of what we are willing to pay for the commodity, less what it costs to supply it. Where an environmental resource simply exists and provides us with products and services at no cost, then it is our *willingness to pay* alone which describes the value of the resource in providing such commodities, whether or not we actually make any payment.

Why then value environmental resources? The answer to this question is that although we know intuitively that such resources may be important, this may not be enough if we are to ensure their wise use. Many environmental resources are complex and multi-functional, and it is not obvious how the myriad goods and services provided by these resources affect human welfare. In some cases, it may be worthwhile to deplete or degrade environmental resources; in others, it may be necessary to 'hold on' to these resources. Economic valuation provides us with a tool to assist with the difficult decisions involved.

Loss of environmental resources is an economic problem because important values are lost, some perhaps irreversibly, when these resources are degraded or lost. Each choice or option for the environmental resource – to leave it in its natural state, allow it to degrade or convert it to another use – has implications in terms of values gained and lost. The decision as to what use to pursue for a given environmental resource, and ultimately whether current rates of resource loss are 'excessive', can only be made if these gains and losses are properly analysed and evaluated. This requires that *all the values* that are gained and lost under each resource use option are carefully considered.

For example, preserving an area in its natural state involves direct costs of preservation for setting up a protected area, and in developing countries this may include paying guards and rangers to protect and maintain the area and perhaps the cost of establishing a 'buffer zone' for surrounding local communities. Development options are sacrificed if preservation is chosen, and these foregone development benefits are additional costs associated with the preservation option. Such costs are easily identifiable as they often comprise marketable outputs and income sacrificed (e.g., fisheries' revenue or subsistence agricultural income, in the case of wetlands). It is not surprising therefore that governments and donors usually consider the *total costs* – the direct costs plus the foregone development benefits – of preservation when choosing to retain an environmental resource in its natural or a managed state.

But the same approach should be taken in evaluating the development options for the environmental resource. For example, if the environmental resource is to be converted to some other use, not only should the direct costs of conversion be included as part of the costs of this development option but so must the *foregone* values that the converted resource can no longer provide. These may include the loss of both important environmental functions and, in the case of complex resource systems such as wetlands, many important biological resources and amenity values as well. Unfortunately, many of these values of the natural or managed environmental resource are not bought and sold on markets, and thus are generally ignored in private and public development decisions.

For example, the market value of environmental resources converted to some commercial use may fail to reflect the lost environmental benefits. Development decisions are therefore often *biased* in favour of those uses of environmental resources which do have marketed outputs. Thus, the failure to account more fully for the economic costs of conversion or degradation of environmental resources is a major factor behind the design of inappropriate development policies. The result is too much conversion and over-exploitation of environmental resources. As this failure is endemic in private and public decisions concerning the use of environmental resources – particularly wetland resources – it is necessary to assess more fully the net economic benefits arising from different wetland uses.

Valuation is only one element in the effort to improve management of environmental resources such as wetlands. At the same time, decision-makers must take account of many competing interests in deciding how best to use wetlands. Economic valuation may help inform such management decisions, but only if decision-makers are aware of the overall objectives and limitations of valuation.

The main objective of valuation in assisting wetland management decisions is generally to indicate the overall *economic efficiency* of the various competing uses of wetland resources. That is, the underlying assumption is that wetland resources should be allocated to those uses that yield an overall net gain to society, as measured through valuation in terms of the economic benefits of each use less its costs.[1] Who actually gains and loses from a particular wetland use is not part of the efficiency criterion *per se*. Thus a wetland use showing a substantial net benefit would be deemed highly desirable in efficiency terms, even though the principal beneficiaries may not necessarily be the ones who bear the

1 Under certain conditions, it can be demonstrated that this welfare-maximizing allocation of resources satisfies the criterion that economists term 'Pareto efficiency', i.e., any other allocation in the economy could only make some people better off by making others worse off.

burden of the costs arising from the use. If this is the case, then this particular wetland use may be efficient but it may also have significant negative distributional consequences. It is therefore often important that many proposed wetland investments or management policies are assessed not only in terms of their efficiency but also their distributional implications.

Economic valuation is also not a panacea for decision-makers making difficult choices concerning the management of wetland resources. Too often, decision-makers have already decided on what wetland management strategy to pursue, whether conversion or conservation, and simply want economic valuation to confirm this choice *ex post facto*. In such circumstances, valuation has done little to inform the decision-making process and essentially serves no purpose. At the other extreme, sometimes decision-makers ask the impossible from economic valuation. A major difficulty facing valuation of a complex environmental system such as wetlands is insufficient information on important ecological and hydrological processes that underpin the various values generated by the wetlands. If this information is lacking – which is often the case for many non-market environmental values that may be deemed important to value – then it is incumbent upon the analysts conducting the valuation to provide realistic assessments of their ability to value key environmental benefits. Equally, decision-makers must realise that under such circumstances valuation cannot be expected to provide realistic estimates of non-market environmental values – not, at least, without further investment of time, resources and effort in further scientific and economic research.

Finally, economic valuation is concerned ultimately with the allocation of wetland resources to improve human welfare. Consequently, the various environmental benefits of wetlands are measured in terms of their contribution to providing goods and services of value to humanity. However, some members of society may argue that certain wetland systems and the living resources they contain may have an additional ‘preeminent’ value in themselves beyond what they can provide in terms of satisfying human preferences or needs. From this perspective, preserving wetland resources is a matter of moral obligation rather than efficient or even fair allocation. There may be other motivations for managing wetlands in particular ways, such as political considerations. Thus, economic values represent just one input into decision-making, alongside important other considerations. The goal of this text is to assist planners and decision-makers with increasing the input from economic valuation in decision-making.

2.2 The economic values of wetlands

If researchers are to value wetland uses and decision-makers are to take these into account when making policies that affect wetlands, then a framework for distinguishing and grouping these values is required. The concept of *total economic value* (TEV) provides such a framework and there is an increasing consensus that it is the most appropriate one to use. Simply put, total economic valuation distinguishes between *use* values and *non-use* values, the latter referring to those current or future (potential) values associated with an environmental resource which rely merely on its continued existence and are unrelated to use (Pearce and Warford, 1993). Typically, use values involve some human 'interaction' with the resource whereas non-use values do not. The total economic valuation framework, as applied to wetlands, is illustrated in Table 2.1.

Use values are grouped according to whether they are *direct* or *indirect*. The former refers to those uses which are most familiar to us: harvesting of fish, collection of fuelwood and use of the wetlands for recreation (Table 2.1 lists several others as well). Direct uses of wetlands could involve both commercial and non-commercial activities, with some of the latter activities often being important for the subsistence needs of local populations in developing countries or for sport and recreation in developed countries. Commercial uses may be important for both domestic and international markets. In general, the value of marketed products (and services) of wetlands is easier to measure than the value of non-commercial and subsistence direct uses. As noted above, this is one reason why policy makers often fail to consider these non-marketed subsistence and informal uses of wetlands in many development decisions.

Table 2.1 Classification of total economic value for wetlands

USE VALUES			NON-USE VALUES
Direct Use Value	**Indirect Use Value**	**Option and Quasi-Option Value**	**Existence Value**
• fish • agriculture • fuelwood • recreation • transport • wildlife harvesting • peat/energy	• nutrient retention • flood control • storm protection • groundwater recharge • external ecosystem support • micro-climatic stabilisation • shoreline stabilisation, etc.	• potential future uses (as per direct and indirect uses) • future value of information	• biodiversity • culture, heritage • bequest values

Source: adapted from Barbier (1989b, 1993, 1994) and Scodari (1990)

In contrast, various *regulatory ecological functions* of wetlands may have important indirect use values. Their values derive from supporting or protecting economic activities that have directly measurable values. The indirect use value of an environmental function is related to the change in the value of production or consumption of the activity or property that it is protecting or supporting. However, as this contribution is unmarketed, goes financially unrewarded and is only indirectly connected to economic activities, these indirect use values are difficult to quantify and are generally ignored in wetland management decisions.

For example, the storm protection and shoreline stabilisation functions of a wetland may have indirect use value through reducing property damages, yet often coastal or riverine wetland systems are drained in order to build still more waterfront property. Mangrove systems are known to be breeding grounds and nurseries for shrimp and fish that are essential for coastal and marine fisheries, yet these important habitats are currently being converted rapidly in many regions for aquaculture, particularly shrimp ponds. Natural floodplains may recharge groundwater used for dryland agriculture, grazing livestock and domestic or even industrial use, yet many of these floodplains are threatened by dams and other barrages diverting water for upstream irrigation and water supply.

A special category of value is *option value*, which arises because an individual may be uncertain about his or her future demand for a resource and/or its availability in the wetland in the future. In most cases, the preferred approach for incorporating option values into the analysis is through determining the difference between *ex ante* and *ex post* valuation.[2] If an individual is uncertain about the future value of a wetland, but believes it may be high or that current exploitation and conversion may be irreversible, then there may be *quasi-option value* derived from delaying the development activities. Quasi-option value is simply the expected value of the information derived from delaying exploitation and conversion of the wetland today. Many economists believe that quasi-option value is not a separate component of benefit but involves the analyst in properly accounting for the implications of gaining additional information.[3]

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2 This is done by developing well-specified models of individual choice, through reasoning about how marginal utility of income differs in the various contingency states (Smith, 1983, Freeman, 1984)

3 Quasi-option value can be calculated with an analysis of the conditional value of information in the decision problem (Fisher and Hanemann, 1987)

In contrast, however, there are individuals who do not currently make use of wetlands but nevertheless wish to see them preserved 'in their own right'. Such an 'intrinsic' value is often referred to as *existence value*. It is a form of non-use value that is extremely difficult to measure, as existence values involve subjective valuations by individuals unrelated to either their own or others' use, whether current or future. An important subset of non-use or preservation values is *bequest value*, which results from individuals placing a high value on the conservation of tropical wetlands for future generations to use. Bequest values may be particularly high among the local populations currently using a wetland, in that they would like to see the wetland and their way of life that has evolved in conjunction with it passed on to their heirs and future generations in general. While there are few studies of non-use values associated with wetlands (see the case study involving the UK's Norfolk Broads in Section 4.3 for one example), campaigns by European and North American environmental groups to raise funds to support tropical wetlands conservation hint at the magnitudes involved.[4] For example, several years ago the UK's Royal Society for the Protection of Birds (RSPB) collected £500,000 (US$ 800,000) from a one-off membership mailing campaign to help save the Hadejia-Nguru wetlands of Northern Nigeria in West Africa.[5]

2.3 Why wetland resources and systems are under-valued in development decisions

In sum, wetland resources are particularly susceptible to mis-allocation decisions because of the nature of the values associated with them. Wetlands are multi-functional resources *par excellence*. Not only do they supply us with a number of important resource outputs (e.g., fish, fuelwood, wildlife), but they also perform an

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4 Strictly speaking, the amounts collected by environmental groups through mail outs and other techniques cannot be interpreted immediately as 'non-use values' because of the complex motivations people have for contributing. For example, some individuals derive a so-called 'warm glow' from giving to a good cause, which is not related to the cause itself.

5 Ken Smith, RSPB, personal communication.

unusually large number of ecological functions which support economic activity. Many of these latter services are not marketed; that is, they are not bought and sold because the support they provide to economic activity is indirect and therefore largely goes unrecognised. In the case of tropical wetlands, many of the subsistence uses of wetland resources are also not marketed and are thus often ignored in development decisions.

Some of the ecological services, biological resources and amenity values provided by wetlands have the qualities of what economists call a *public good*, so that it would be virtually impossible to market the service, even if this were desired.[6] For example, if a wetland supports valuable biodiversity, all individuals potentially benefit from this service, and no one individual can be excluded from the service. Such situations make it extremely difficult to collect payment for the service, since whether you pay or not, you may still reap the benefit. In such circumstances, wetland services are liable to be undervalued.

Some of the difficulty arising from the public good qualities of wetland values would be unimportant if all wetland benefits could be enjoyed simultaneously, without any conflict among the various uses. Aggregating all possible use values together in such an unfettered multiple-use situation would be more likely to lead to recognition of the importance of conserving a wetland in its natural or a semi-natural state. However, amongst many wetland uses there are inherent conflicts or tradeoffs, even when the wetland is

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6 A *public good* exists where one individual may benefit from the existence of some environmental service or attribute and this does not reduce the benefit another individual can receive for that same service or attribute. This situation contrasts with that of a *private good*, where two individuals cannot jointly consume the good. Another way of clarifying these concepts is to refer to their degree of exclusiveness (whether some people can be refused access to the resource) or rivalness (whether the use of the resource by one individual reduces its possible use by another). Many wetland resource uses are non-exclusive but rival, that is, they are open to all but diminish as use increases. Some are non-rival and non-exclusive – this is the characteristic of ‘pure’ public good, such as biodiversity and non-use values (Aylward, 1992).

maintained in a more-or-less natural state (Turner, 1991). For instance, it may not be possible to manage a wetland for recreation or commercial fishing while at the same time using it for wastewater treatment. Even if the latter use is more valuable, its non-market and public good properties mean that its value is unlikely to be reflected in market decisions automatically. If public policy is to allow individuals responding to market signals to determine the allocation of wetland uses – the so-called 'free market' solution – then it is unlikely that the wetland will be used for wastewater treatment. Thus, the resulting 'undervaluing' of a key ecological service may once again lead to inappropriate wetland uses.

A wetland and its resources may also be undervalued and thus misallocated because of the *property rights* regime governing wetland access and use. For example, the wetlands in question may be subject to *open access*, where no rules apply and use of its resources may be open to all and unregulated. Alternatively, informal and traditional arrangements may govern their use as communal or *common property* resources. Finally, state or private property may characterize the wetland resource base (Bromley, 1989). Each form of property rights may be characterized by quite distinct conditions of resource exploitation. For instance, open-access resources are often over-harvested, so observed use values may be very low. As a result, if attempts to value environmental resources are based on simple observations of current use rates, without taking into consideration the institutional context, they may undervalue the resource. This may be especially important if the institutional arrangement is changing informally, as when indigenous common property systems are reasserted after a period of dormancy, or a change has been mandated as an element in a project or programme affecting a wetland area, as when land is suddenly privatized or nationalized.

Undervaluing of wetlands can be a serious problem when outright conversion of the wetland area is at stake. As noted in previous sections, development or conversion of the wetland tends to produce marketable outputs, while maintaining the wetland in a natural or managed state usually leads to the preservation of non-market goods and services.[7] Such a dichotomy often results in the development option – i.e., conversion to agriculture, fish ponds, and commercial or residential property – being widely regarded as the most valuable wetland use. As such activities also generate additional government revenue, it is not surprising that decision-makers also support the conversion of wetlands to 'commercial' uses.

Even where revenues may not be the primary objective of wetland exploitation and conversion, agriculture, aquaculture, property development and other conversion activities are generally considered important for economic development and regional growth. They are seen as having significant 'linkages' to other sectors, especially processing and construction, and can provide much-sought-after jobs in regions with few other industrial alternatives. These are compelling arguments for planners and decision-makers in many countries for supporting wetland conversion at the expense of other wetland values. In contrast, non-marketed ecological functions and amenity values generated by natural or managed wetlands may create little in the way of spinoff benefits, and instead may even substitute for employment-generating activities (e.g., water treatment, flood control and storm protection) or require additional investments of scarce public resources (e.g., tourist facilities and roads for recreational uses). Some wetlands may also generate negative external effects in the form of support for disease vectors such as malaria-carrying mosquitoes which may be recognised while other indirect support functions are ignored.

In sum, the undervaluing of wetland resources and functions is a major reason why wetland systems are mis-allocated – often to conversion or exploitation activities yielding immediate commercial gains and revenues. Economic valuation may provide decision-makers with vital information on the costs and benefits of alternative wetland use options that would otherwise not be taken into account in development decisions. In Chapter 3, we provide a

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7 Obviously, there are opportunities for sustainable harvesting of some marketable outputs, such as from artisanal fishing and fuelwood collection, but these values are liable to be smaller than the marketed returns from development or conversion.

general appraisal framework for wetland valuation that assists decision-makers in assessing the net economic benefits of alternative wetland use options.

2.4 Why valuation matters to Ramsar

A key concept underlying the principles of the Ramsar Convention is that wetlands have great value. Conservation can only be achieved if wetlands can be shown to be of value and, in some cases, of greater value than proposed alternative uses of the wetland site itself or of the water feeding the wetland. In line with this, Contracting Parties are asked to provide physical and social values of wetlands as part of the information for designation on the List of Wetlands of International Importance. Contracting Parties are also committed to making environmental impact assessments, before initiating schemes that might affect wetlands, which should pay particular attention to maintaining the values of wetlands.

To support the Contracting Parties in this endeavour, the Convention intends to promote the development, wide dissemination and application of documents which give guidance on the economic valuations of the goods and services of wetlands as part of the implementation of its Strategic Plan, 1997-2002. This document thus provides specific guidance on economic valuation techniques and on the use of valuation studies in national wetland policies, regional plans, environmental impact assessments and river basin management.

3. An appraisal framework for wetland valuation

In this chapter, we develop a general framework for assessing the net economic benefits of alternative uses of wetlands.[8] Ideally any assessment ought to lead to an economic valuation of all benefits and costs associated with each wetland use option that is to be evaluated. The assessment methodology developed here is consistent with the economic technique of *cost-benefit analysis*. However, given that data limitations often constrain the analyst's ability to value many environmental functions and resources, it will be necessary to adapt the assessment methodology in such circumstances to provide the best information possible to aid decision-making. Appendix 2 provides a description of alternative assessment methodologies, including cost-effectiveness analysis, multi-criteria analysis and others.

One approach not discussed in Appendix 2 is a Safe Minimum Standard (SMS) decision rule. This technique has relevance where the fate of highly unique wetland resources may be at stake and caution may be advised to avoid potentially large irreversible losses to society (see Box 3.1). Obviously, not all wetland management problems warrant the use of SMS, but when they do, analysts can modify the standard cost-benefit analysis approach accordingly. Regardless of the method selected, an interdisciplinary approach will be needed at virtually all stages in the assessment, and this should particularly involve collaboration between economists and ecologists. Figure 3.1 summarises the overall assessment framework for economic evaluation of wetlands.[9]

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8 The appraisal framework presented in this chapter was developed by E. Barber for IIED (1994). This approach was originally developed for economic valuation of tropical wetlands; see for example, Barber (1989b, 1993 and 1994).

9 Figure 3.1 is adapted from IIED (1994), and was originally developed by E. Barber, R. Costanza and R. Twilley for the 1991 IUCN ORMA (Regional Office for Meso-America) and CATIE workshop on economic valuation of Central American tropical wetlands.

Box 3.1 Applying the precautionary principle to wetland management decisions

Where decisions about the loss of unique ecosystem resources or attributes, such as biodiversity, involve uncertainty, alternatives to the standard cost-benefit analysis may be desirable. Such decision rules must recognise that we are not fully knowledgeable about the potential costs and benefits of wetland use or conversion, nor of their probabilities of occurrence. Although such information might be forthcoming as time passes, it is not available now, and yet important decisions about the conversion or conservation of highly unique wetland resources must be made in the interim. Preference for a risk-averse decision rule (erring on the side of caution) in such situations calls for application of the precautionary principle. In effect, employing such a management decision rule suggests that society may be willing to pay a premium for the conservation of resources whose full value may not yet be known or appreciated, in the same sense that we purchase insurance protection as individuals. In this case, society may wish to take the steps necessary to preserve important wetland resources as long as the cost or "premium" is not too high. Determining just what this limit might be is not easy, but is liable to involve a least-cost perspective. Use of the precautionary principle is evident in such international agreements as the Montreal Protocol on substances *likely* to damage the ozone layer or the Declaration of the Third Ministerial Conference on the North Sea with respect to the dumping of *potentially* toxic materials (O'Riordan and Cameron, 1994).

The argument for applying a precautionary principle hinges on the dilemma that at present we do not know the risks or magnitudes of potential losses from doing nothing. We can guess that these may be quite large and that we might miss out on significant benefits or incur severe losses if key wetland resources are not conserved. Thus, it is argued that the *burden of proof* should be shifted to those who would argue against a safe level of conservation of important wetlands. Stated in this way, we could view the opportunity costs of delaying or prohibiting conversion of highly unique wetlands as part of the insurance premium which we would be willing to pay to conserve these wetlands for the future.

When we do not know the likelihood or magnitude of losses associated with conversion of a wetland, we must seek alternative assessment methods to replace or supplement the standard cost-benefit analysis approach (Tisdell, 1990). One particular approach consistent with the precautionary principle is the safe minimum standard of conservation, originating with Ciriacy-Wantrup (1952). The term originally referred to a conservation strategy applicable to wild species with a critical threshold population size below which they could not recover (minimum viable population). Its aim was to ensure that at least this minimum population size was maintained as long as the cost of doing so was not intolerably high. Such an approach could equally be applied to unique wetland resources, especially if it is used in association with conventional cost-benefit analysis (Tisdell, 1990). The SMS is usually presented as a decision technique making use of game theory which adapts easily to situations where the probability of gains and losses are not known (Bishop, 1978; Ready and Bishop, 1991). Game theory therefore provides a useful framework for analysing problems involving highly unique wetlands.

This evaluation process involves three stages of analysis:

- *Stage 1* – Defining the problem and choosing the correct economic assessment approach.

- *Stage 2* – Defining the scope and limits of the analysis and the information required for the chosen assessment approach.

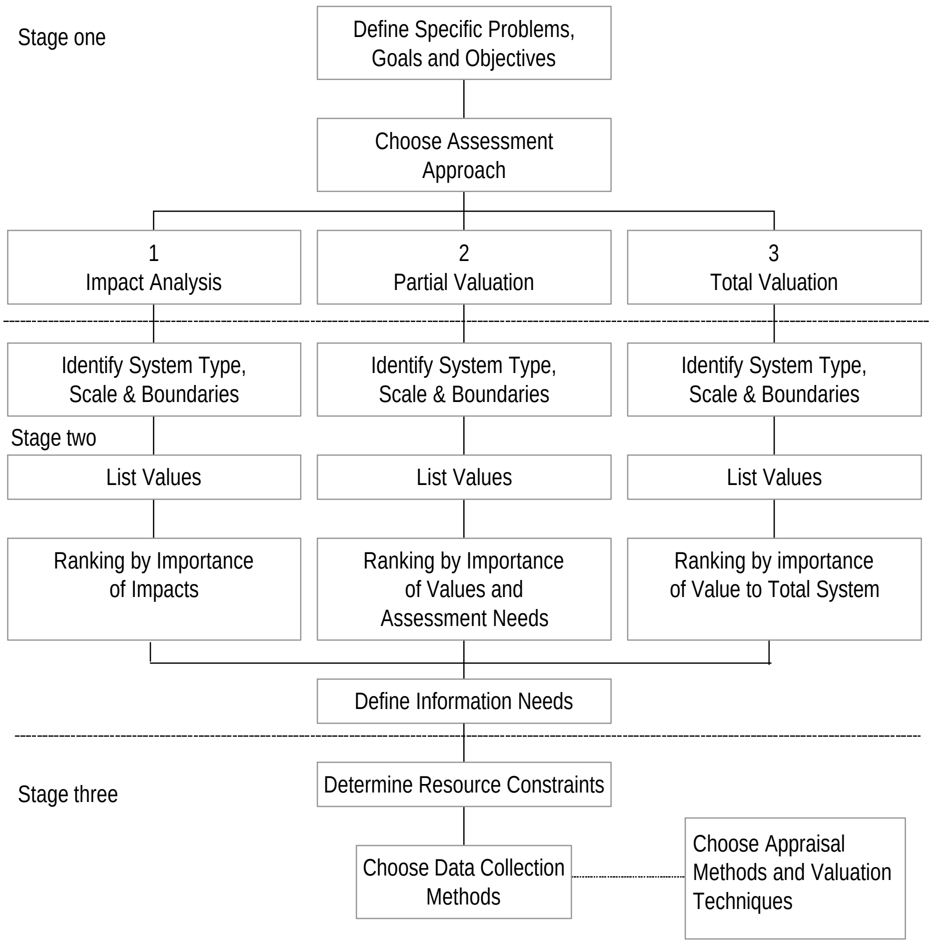
- *Stage 3* – Defining data collection methods and valuation techniques required for the economic appraisal, including any analysis of distributional impacts.

The first stage is necessary to determine the correct assessment approach required for the particular wetland that is to be evaluated. The second is to determine the information needs for carrying out the selected assessment approach. The third is the choice of appropriate economic appraisal methods and valuation techniques. The completion of all three stages of the analysis should yield an economic evaluation of the wetland that will indicate to policy makers whether that option should proceed or not.

Although the three stages in the analysis have the appearance of being sequential, which is also the impression given in Figure 3.1, actual implementation of the assessment should involve an iterative, or 'feedback', process. That is, at any stage in the analysis, it may be necessary to return to a previous stage in order to revise the assessment process, improve the analysis, redefine information needs, and so forth. Several such iterations may be necessary before the economic evaluation can be successfully concluded.

The aim of the three-stage process outlined in Figure 3.1 is an *economic assessment* of wetland values. All wetland values assessed should reflect the true 'willingness to pay' by society for their benefits. This will require determining the true economic value of benefits that are essentially non-marketed and adjusting the market prices of some wetland goods and services for distortions caused by government policies or market imperfections. However, in some instances, data and resource constraints may limit the analysis to a *financial assessment*. Only marketed goods and services can be valued, through the use of 'unadjusted' market prices.

Figure 3.1 The assessment framework for economic valuation of wetlands



Source: adapted from IIED (1994).

In either case, it is normal practice to *discount* annual values to a *present value* figure. This requires the analyst to select a discount rate (see Box 3.2). In some cases, the analysis may be limited to just a *physical assessment*. Neither financial nor economic values are possible to determine, but one may be able to indicate the physical changes in the goods and services provided by the wetlands or in any environmental impacts.

In the discussion that follows, three stages of the appraisal process are illustrated by assuming that a full economic assessment is the ultimate objective.

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3.1 Stage one: defining the problem and assessment approach

The first stage in the evaluation process is to determine the overall objective or problem. As indicated in Figure 3.1, the type of economic assessment approach chosen will depend directly on the problem confronting the analyst.

Three broad categories of issues are of most relevance to the economic analysis of wetlands. Corresponding to each of these three evaluation objectives would be a specific economic assessment approach. As shown in Figure 3.1, these are:

- *impact analysis* – an assessment of the damage inflicted on the wetland from a specific external environmental impact (e.g., oil spills on a coastal wetland)
- *partial valuation* – assessment of two or more *alternative wetland use options* (e.g., whether to divert water from the wetlands for other uses, or to convert/develop part of the wetlands at the expense of other uses)
- *total valuation* – assessment of the *total economic contribution*, or net benefits, to society of the wetland system (e.g., for national income accounting or to determine its worth as a protected area).

The advantage of such a framework is its flexibility. Data and analysis may be tailored to the specific needs of policy makers.

Box 3.2 Time and discounting in economic valuation

When economists evaluate benefits and costs which extend over more than one time period, they can use one of two approaches. In the first case, they must make allowance for the fact that individuals view more distant benefits and costs differently than more immediate ones. Generally, the pattern observed is that we prefer costs to be postponed and benefits to be received as soon as possible (for a critique of this approach, see Price (1993)). This situation is referred to as *time preference* and is mimicked by financial institutions in that they must pay interest on deposits, reflecting the need to return a higher amount to the individual at a later date in order to make use of these funds in the interim. To account for time preference in valuation and cost-benefit studies, economists use a *discount rate* to weight benefits and costs occurring in different time periods, similar to the payment of interest on bank accounts. Since we would prefer having a sum of money in the present to waiting until a later time period for it, we weight current values more heavily than ones in distant periods. To accomplish this, we use a discount factor which incorporates the discount rate selected. Weighting a series of benefits or costs, and summing these, yields a *present value*. Once we have calculated the present values of benefits and costs, we normally take the difference between the two, the *net present value*, as an indicator of a project's viability in economic terms.

A second approach is to look at the *opportunity cost of capital* invested in a project, which refers to the profits which could have been obtained by investing this capital in the next best possible opportunity. These foregone profits represent the cost of the capital employed in the project, and the net benefits (i.e., benefits minus costs) of our project must at least equal these foregone profits if it is to be considered viable. Thus, when weighting benefits and costs in different time periods we use the opportunity cost of capital as our discount rate to reflect what the project should be generating in terms of benefits, if it is to be an attractive investment.

The choice of a discount rate is a controversial matter, and will depend in part on whether we are using a time preference or an opportunity cost of capital approach. In addition, some researchers argue that the discount rate should be high, since many projects impose damage on the environment and should be penalised, while others argue that no discount rate should be used at all, to incorporate sustainability considerations and the interests of future generations. The effects of projects on the environment range widely, suggesting that an appropriate choice of discount rate might be expected also to vary with the circumstances. However, this creates difficulties, since it is generally preferable to use a single rate for all projects evaluated to ensure consistency and to allow for comparisons amongst different projects. If this is done (as opposed to a separately determined discount rate for each project), then the overall impact of high or low discount rates on the environment becomes ambiguous: with a high discount rate, for example, environmentally damaging projects are discouraged and the overall level of investment, and therefore the rate of natural resource use, declines, but this comes at the expense of weighting the consumption of the current generation higher than that of future generations (Pearce, Markandya and Barbier, 1989). As a result, there is an emerging consensus that no adjustment be made to the standard economy-wide discount rate when evaluating environmental values, and instead other techniques should be used to adjust for any special conditions associated with environmental benefits and costs (Markandya and Pearce, 1988).

For example, there may be no need to value alternative land uses if the relevant issue is the external impact of a specific activity. Similarly, there may be no need to estimate the total economic value of wetlands under all potential uses if policy makers want to compare the relative costs and benefits of only a limited number of alternative proposals.

Before considering Stages 2 and 3 of the assessment process, it is worth briefly explaining what is involved in each of the above assessment approaches.

Impact Analysis

The first approach, *impact analysis*, is most relevant in situations where disturbance of a particular wetland results in specific environmental impacts.[10] For example, assume that discharges of oil are regularly polluting an estuarine wetland, affecting both fish production and water quality in the wetlands. The *costs* of this activity are the *losses in wetland values* arising from damage to the ecosystem and its resources. These damages would amount to the losses in *net production benefits* (i.e., the economic benefits of production less the costs) from the impacts of the oil spills on the fishery plus the losses in *net environmental benefits* in terms of poorer quality water supplies for wetland and neighbouring settlements, as well as for general ecosystem functioning. Thus, by assessing and valuing these losses, we would arrive at an estimate of the net production and environmental benefits of the wetlands lost as a result of the oil spills. The total cost of this impact in terms of damage to the wetland are these foregone net benefits.

Essentially, what the impact analysis is telling us is that oil exploitation is imposing external costs on the wetland system. These off-site costs must be weighed against the *net benefits gained* from additional oil developments. Thus only by assessing

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10 Impact analysis, as referred to here, should not be confused with Environmental Impact Assessment (EIA), which represents an appraisal method, as described in Appendix 2. Here, we are concerned with defining the appropriate way of viewing the problem, whilst EIA represents a tool for understanding an appraisal.

and valuing the external losses from reduced water quality and fish production in the wetlands would we arrive at a true measure of the net benefits of the oil development (see Box 3.5). Even if these net benefits from development exceed the costs of the impacts or oil discharges, calculation of the impacts on the wetlands may be important for determining whether it is worth investing in pollution abatement.

As discussed in Section 2.1, it may also be important from a policy perspective to assess the distributional impacts of wetland modifications, in terms of which communities are affected the worst. Finally, if the offsite costs of wetland disturbance are irreversible, then it may be economically efficient to continue with oil developments in the short term, but this outcome may not be *sustainable* over the long term.[11]

Partial Valuation

A second type of cost-benefit assessment, *partial valuation*, is the principal method used to evaluate alternative wetland use options. That is, choices involving diversion, allocation or conversion of wetland resources should compare the net benefits generated by each of the wetland uses. For example, assume that there is an upstream irrigation project on a river that is providing water for agriculture. If this project diverts water from a wetland downstream, then any resulting loss in wetland benefits must be included as part of the overall costs of the project. If the foregone wetland benefits are significant, then the failure to assess the loss of wetland benefits will clearly lead to an overestimation of the true net benefits of the development projects (see Box 3.5). This is tantamount to assuming that there is no economic cost of diverting floodwater from the wetlands, which is rarely the case. Moreover, it may not be necessary to measure all affected wetland benefits; for example, one or two impacts may prove to be sufficiently large to render the development project uneconomic. In any case, it is not necessary to measure all wetland benefits but only those benefits which are affected by the development project – which is why this approach is called a 'partial valuation'.

11 For further discussion on this issue, see Barber, Markandya and Pearce (1990).

Box 3.3 Examples of impact analysis applied to economic valuation

Dixon and Hufschmidt (1986) and Dixon *et al.* (1988) illustrate the application of impact analysis in determining the cost-effectiveness of various options for disposing of waste water from a geothermal power plant on the island of Leyte in the Philippines. In this case, it was necessary to decide which means of waste water disposal from the plant would protect the environment in the most cost-effective manner. For some of the options, the costs of the environmental impacts in terms of lost marine fishery and rice production were quantified. Other environmental costs, such as energy loss, lost riverine fishery production, human health effects and amenity impacts, were not possible to quantify. For example, the analysis showed that the quantifiable environmental costs of releasing untreated waste disposal into the Bao River or into the Mahiao River were quite high, accounting for 41% and 35% of total measurable costs of these options respectively. Both options may also seriously contaminate the marine ecosystem with unknown and unquantifiable effects. The result was that consideration of the quantifiable and unquantifiable environmental impacts made reinjection of wastewater into the geothermal source the more attractive option.

Impact analysis has also been applied to the assessment of agricultural programmes and policies which may have unintended impacts on wetlands. Several studies, for example, have considered the role of agricultural support prices or public infrastructure investments in causing losses of economic values associated with North American wetlands (van Kooten, 1993; Stavins and Jaffe, 1990). Such policies may be intended to encourage an expansion in cultivated land area but often do not give consideration to the wetland values forsaken. If these values were to be taken into account, the net benefits of the government programme would be much lower than anticipated. Ironically, many governments do provide assistance to farmers to encourage retention of important wetland habitat, while at the same time maintaining incentives to drain wetlands. However, Van Kooten, for example, shows that to offset the impacts of the Canadian government's agricultural support policies on prairie wetlands, prairie farmers would need to receive an incentive of C$ 55 (US$45) per acre (1988 prices). In fact, the government at that time paid out incentives to retain wetlands of at most C$ 30 (US$ 24) per acre. In the absence of agricultural support payments, an incentive sufficient to encourage conservation of these private wetlands would have been much lower.

Box 3.4 Examples of partial analysis applied to wetlands valuation

A few examples may help to illustrate the partial valuation approach. An analysis by Barbier *et al.* (1993) following this approach was conducted for the Hadejia-Jama'are floodplain in Northern Nigeria, which is being threatened by upstream water developments. The analysis shows that the floodplain agricultural, fishing and fuelwood net benefits are much more substantial than the net benefits of an upstream irrigation project, which is diverting water from the wetlands. For example, the authors estimated the net present value of agricultural, fishing and fuelwood benefits from the wetlands to be N253 to 381 ($US 34 to 51) per hectare (in 1989/90 prices), while the net present value of benefits from diverting streamflow to the irrigation project were only N153 to 233 ($US 20 to 31) per hectare. An even more pronounced divergence was noted when benefits were calculated on the basis of water use (e.g., per thousand cubic metres) rather than land area.

Hanley and Craig (1991) conducted a partial valuation of alternative uses of peat bog in Northern Scotland's 'Flow Country'. This large area of blanket peat bog, covering over 400,000 hectares, has many unique plants and the area is an important bird habitat. It has been subjected to conversion through planting of pine and spruce in block plantations. Damage to the bog area results from habitat disturbance, disruption of water and soil regimes, and increased sedimentation and erosion, and there is a net release of carbon to the atmosphere. The authors calculate the net benefits of tree planting and estimate that the net present value of an infinite rotation is *negative*, at £895 (US$ 1595) per hectare (in 1990 prices), suggesting that it is only as a result of government incentive payments that planting has occurred (*N.B.* these payments have since been withdrawn). The benefits of retaining the area in its natural state were assessed using a survey questionnaire to solicit individuals' *willingness-to-pay* for conserving the area (see Box 3.8). The net present value of conserving the area was estimated at £327 (US$ 580) per hectare, which contrasts with the already negative figure arrived at for converting the bog area to block plantations.

Chapter 4 provides full descriptions of these case studies.

Total Valuation

The third assessment approach, *total valuation*, is most appropriate where a full accounting of the costs and benefits associated with retaining a particular wetland is required.

Box 3.5 Impact, partial and total valuations – a more formal analysis

The assessment approaches described in the main text – impact, partial and total valuation – can also be defined in a more formal, mathematical way, which helps clarify the distinctions. For **impact analysis**, we can use the example of regular oil discharges polluting a wetland, cited earlier. Losses in *net production benefits* from the impacts of the oil spills on the wetland's fishery plus the losses in *net environmental benefits* (i.e., poorer quality water supplies for wetland and neighbouring settlements, as well as for general ecosystem functioning) can be referred to as NB^W. The total costs of the impact on the wetlands, C^I, are these foregone net benefits:

$$C^I = NB^W$$

If NB^D is the direct net benefits of oil production, from society's perspective, additional oil exploitation is worthwhile only if:

$$NB^D > C^I$$

For **partial valuation**, assume as in the main text an upstream irrigation project diverting water from a downstream wetland, resulting in losses in wetland benefits. These losses must be included as part of the overall costs of the project. Given *direct benefits* (e.g., irrigation water for farming), B^D, and *direct costs* (e.g., costs of constructing the dam, irrigation channels, etc.), C^D, then the *direct net benefits* of the project are:

$$NB^D = B^D - C^D.$$

However, by diverting water that would otherwise flow into the downstream wetlands, the development project may result in losses to floodplain agriculture and other primary production activities, less groundwater recharge and other external impacts. Given these reductions in the *net production and environmental benefits*, NB^W, of the wetlands, then the true net benefits of the development project (NB^P) are $NB^D - NB^W$. The development project can therefore only be acceptable if:

$$NB^P = NB^D - NB^W > 0$$

An objective requiring **total valuation** might be (as in the main text) the need to determine whether or not the wetlands should become a protected area. The total net wetland benefits, NB^W, would therefore have to exceed the direct costs, C^P, of setting up the protected area, including any costs of relocating or compensating existing users, plus the net benefits foregone, NB^A, of alternative uses of the wetlands:

$$NB^W > C^P + NB^A .$$

Box 3.6 Examples of total valuation applied to wetlands

Several examples of total valuation studies of wetlands can be cited. Again considering Louisiana's coastal wetlands, Costanza, Farber and Maxwell (1989) attempted a total valuation which included benefit estimates for commercial fisheries, trapping, recreation and storm protection. Using a variety of techniques, the authors estimate the total value of these key benefits provided by the wetlands at $US 2,429 per acre (using an 8% discount rate). Commercial fishing and trapping account for 19% of the total, recreation for 2% and storm protection services make up the remainder. Chapter 4 provides a full description of this study.

Gren (1994) conducted a total valuation study of the Danube River floodplains to assist with determining the potential benefits from improving the water quality and overall management of the Danube. Although some values are based on *benefits transfers* (see Box 3.7), credible estimates are made of the key resource products harvested from the floodplains (e.g., wood products, fodder and fish), as well as for recreation and nitrogen retention, which is an important ecological function in such a polluted river system. The total economic value of these major uses of the floodplains is $US 458 per hectare per year (1993 prices). Of this total, their role as a nitrogen sink represents 56% of the total and recreation accounts for 29%. The remaining 15% comes from harvesting of wood products, fodder and fish.

For example, as part of a natural resource accounting exercise, it may be necessary to measure the total economic contribution of a particular wetland to the welfare of society as a whole. In this case, the aim is to value as many of the net production and environmental benefits associated with the wetland as possible.[12]

Another objective requiring total valuation would be the need to determine whether or not the wetlands should become a protected area with restricted or controlled use. The total net wetland benefits would therefore have to exceed the direct costs, C^P, of setting up the protected area (including any costs of relocating or compensating existing users), plus the net benefits foregone of *alternative uses of the wetland.*

12 For further discussion of the methods of resource accounting as applied to environmental resources, see Lutz (1993).

3.2 Stage two: defining the scope and limits of the valuation and information needs

After the appropriate economic assessment approach for the stated problem is identified, the next step is to define the analysis and information needs required to conduct the assessment. The first step is to identify the wetland area under consideration, the time scale of the analysis and the geographic and analytical boundaries of the system. These will obviously differ given the type of problem to be analysed. For example, an impact analysis of the effects on a wetland of changes in water quality and flow would have to include both activities within its 'analytical' boundary and a time horizon sufficient to cover the duration of the changes in the water flow regime and the impacts of deteriorating water quality. In contrast, any attempt to measure the total economic contribution of a particular wetland to the welfare of society as a whole would have to have an extremely wide analytical boundary, sufficient to cover all possible social values of the wetlands, as well as a very long time horizon, perhaps sufficiently long to include inter-generational implications.

Once the system and analytical boundaries are defined, further analysis is needed to determine the basic characteristics of the wetland being assessed. In an economic assessment, we are essentially concerned with 'valuing' these characteristics. In ecology, a distinction is usually made between the regulatory environmental functions of an ecosystem (e.g., nutrient cycles, micro-climatic functions, energy flows, etc.) and its structural components (e.g., biomass, abiotic matter, species of flora and fauna, etc.). This distinction is useful from an economic perspective, as it corresponds to the standard categories of resource stocks or goods (e.g., the structural components) versus environmental flows or services (i.e., the ecological functions). Economics also tends to make a distinction between *consumptive uses* of resources (e.g., fish, fuelwood, wild foods, etc.) and *non-consumptive uses* of a natural system's 'services' (e.g., recreation, tourism, educational use, etc.). In addition, ecosystems as a whole often have certain *attributes* (biological diversity, cultural uniqueness/ heritage) that have economic value either because they induce certain economic *uses* or because they are valued in themselves.

Box 3.7 Benefits transfer: shortcut or misleading technique?

Benefits transfer refers to the practice of using values estimated for an alternative policy context or site as a basis for estimating a value for the policy context or site in question. Benefits transfer studies are often the only recourse where data is poor or funds are not sufficient for a full-scale valuation study. For example, Gren (1994) describes a total valuation study where the benefits of nitrogen abatement at wetlands along the Danube River are estimated using information for wetlands on the island of Gotland in Sweden. Whether this practice is advisable depends on a number of factors, not least of which is the similarity of the sites. Benefits transfer may be questionable or misleading in some cases, so that the familiar argument that some number is better than no number may not hold. A decision about whether to proceed with original data gathering to estimate some wetland value must weigh the costs of collecting this information against the disadvantages of not having such information. In the latter case, a benefits transfer study may well be a viable alternative, but this will hinge on the policy question being addressed and the availability of original benefit estimates as a basis for a benefits transfer.

Krupnick (1993)[1] discusses the situations where a benefits transfer may be appropriate and points out that the valuation of health impacts may be more amenable to benefits transfer than the valuation of other impacts, such as changes in recreation values. Since the impact of environmental change affects individuals indirectly, via their perception of their health status, studies of the value individuals place on avoiding health problems can be used independently of the source of a specific problem, as long as appropriate caution is maintained. A case study of nitrogen abatement using wetlands, described in Chapter 4 (Gren, 1995), takes this approach, making use of estimates of the value individuals place on reduced nitrate concentrations in drinking water, which is independent of how the nitrate is removed. For recreation, an important wetland use value, there is greater difficulty in using benefits transfer, since values tend to be highly reliant upon site and sample population characteristics. Studies also may differ in focus, as in analysing changes in quantity as opposed to quality. Where visual attributes are at stake, there are liable to be even more problems with the use of benefits transfer.

What is lacking at present are well-defined protocols, such as have begun to emerge for valuation techniques like contingent valuation (see Box 3.8). Krupnick hints at some possible guidelines for planners considering the use of benefits transfer. Obviously, the more similar are, not only the sites, but also the characteristics of markets and users, the more appropriate is a benefits transfer. Where demand or value functions are reported in original studies, these should be used along with variable observations for the site or population under study, rather than using simple average unit values from the source study. More important, the need for benefits transfer suggests that more attention should be paid to the design of studies collecting original data to incorporate measures which would make their use in benefits transfer situations easier. Fuller reporting of methodologies and data used in original data studies, including mean values of independent variables and equations used to estimate economic values, would be a step in the right direction. Certainly, any planner contemplating the use of benefits transfer to estimate wetland values should carefully evaluate the original data studies to be used to ensure their appropriateness for the task.

1. A special issue of *Water Resources Research* (vol. 28, no 3) also contains a series of papers on benefits transfer.

The next step is to determine the type of value associated with each of the wetland system's structural components, functions and attributes. Earlier it was helpful to distinguish between *direct use* values (e.g., the values derived from direct use or interaction with a wetland's resources and services); *indirect use* values (the indirect support and protection provided to economic activity and property by the wetland's natural functions, or regulatory 'environmental' services); and *non-use* values (values that are not derived from current direct or indirect uses of the wetlands). This grouping should be used when translating the characteristics of the wetland into economic terms.

Section 2.2 indicated the major types of economic values associated with wetlands, which correspond to the general wetland resources, functions and attributes listed in Appendix 1. Depending on the wetland system and the management problem, different ecological characteristics and economic values will be considered important. Once the major characteristics and values have been identified, they need to be *ranked*. The basis for ranking will again vary with the assessment approach. For example, in an impact analysis the criteria for ranking would most likely be based on which of the wetland's resources, functions and attributes are most affected by the impacts that are being assessed. For a partial valuation, it is important to identify the relative importance of different values and to determine the 'cost effectiveness' of acquiring and assessing the data. That is, in comparing alternative wetland uses, one must determine which of the wetland's resources, functions and attributes are critical for evaluating the alternative options and how easy is it to quantify and value them. For a total valuation, the criteria will be similar, but as the goal is to estimate the total economic contribution of the wetlands, one should at the very least choose to assess those characteristics that contribute most to the total value and if possible attempt to estimate all the major values. In contrast, under a partial valuation, one would value those characteristics that were both important and appropriate to estimate first, and proceed to more difficult values only as necessary. For instance, measuring existence values is difficult and should be attempted only as a last resort where more readily measured values fail to demonstrate that conservation is the preferred option. The Hadejia-Nguru floodplain, for example (see Section 4.1), takes this approach, but is able to demonstrate that conservation is preferred without reverting to measurement of existence value.

Tables 3.1 and 3.2, using examples from Central America, illustrate the importance of determining and ranking the relevant direct and indirect use and non-use values for different wetland systems. The two examples involve a freshwater wetland system in Guatemala and a coastal mangrove system in Nicaragua.

The Petexbatun wetlands are a freshwater system located in Peten State of Northern Guatemala (Table 3.1). As it is a remote system in a dense tropical forest region, the most important direct-use values are derived from the wetlands' forest resources and the system's water supply. The most important ecological functions are flood and water flow control of the Petexbatun River, shoreline/bank stabilisation, sediment retention and external 'nutrient' support to important riverine fisheries. An essential environmental service provided by the wetlands is their direct use for water transport by local populations. The direct, indirect and non-use values of the biodiversity of the system are not particularly significant, and there is little to suggest that the wetlands have unique cultural or heritage value.

The North Pacific Coast mangrove wetlands are located near the large port of Corinto, Nicaragua (Table 3.2). The mangrove system has similar important direct use values to the Guatemalan freshwater wetlands: exploitation of forest resources, water supply and water transport. However, the location of the mangrove wetlands near Corinto port and in an area of important agricultural and fishing activity suggests that they provide some key environmental services. In an area highly susceptible to hurricanes and other tropical storms, the storm protection, wind break and water flow/control functions of the mangrove swamps may prove critical. Similarly, the sediment and nutrient retention capability of the mangroves may reduce dredging costs for the port and key waterways. Finally, as a shrimp and fish breeding ground and hatchery, the mangroves provide important external support for the offshore fisheries in the area. There appears to be nothing particularly unique about the biodiversity of the wetland system, but as the site of original settlements and waterways in Nicaragua, the wetlands may have some heritage value.

Table 3.1 Use of wetland characteristics: Petexbatun, Peten State, Guatemala

Economic values	direct	indirect	non-use
Components/assets			
1. Forest resources	◆◆◆		
2. Wildlife resources	◆		
3. Fisheries	◆◆		
4. Forage resources	◆◆		
5. Agricultural resources	◆◆		
6. Water supply	◆◆◆		
Functions/services			
1. Groundwater recharge		◆	
2. Flood and flow control		◆◆◆	
3. Shoreline/bank stabilisation		◆◆◆	
4. Sediment retention		◆◆◆	
5. Nutrient retention		◆/◆◆	
6. External support		◆◆◆	
7. Recreation/tourism		◆	
8. Water transport		◆◆◆	
Diversity/attributes			
1. Biological diversity	◆◆	◆◆	◆◆
2. Uniqueness / cultural heritage			◆

Key: ◆ = low ◆◆ = medium ◆◆◆ = high

Source: Adapted from Barbier (1989a and 1989b).

Identifying system and analytical boundaries, listing characteristics and values and ranking them in terms of importance to the assessment are all important steps in defining the information required for the analysis. If these information needs are correctly appraised, it is easier to determine the resource constraints to obtaining this information, the data collection methods required and the appropriate choice of valuation techniques.

Table 3.2 Use of wetland characteristics: North Pacific Coast mangroves, Area 1, Nicaragua

Economic values	direct	indirect	non-use
Components/assets			
1. Forest resources	◆◆◆		
2. Wildlife resources	◆		
3. Fisheries	◆◆		
4. Forage resources	◆		
5. Agricultural resources	◆◆		
6. Water supply	◆◆◆		
Functions/services			
1. Groundwater recharge		◆◆	
2. Flood and flow control		◆◆◆	
3. Shoreline stabilisation		◆◆	
4. Sediment retention		◆◆◆	
5. Nutrient retention		◆◆◆	
6. Water quality maintenance		◆◆	
7. Storm protection/wind break		◆◆◆	
8. External support		◆◆◆	
9. Microclimate stabilisation		◆◆	
10. Recreation/tourism		◆◆	
11. Water transport		◆◆◆	
Diversity/attributes			
1. Biological diversity	◆	◆	◆
2. Uniqueness / cultural heritage			◆◆

Key: ◆ = low ◆◆ = medium ◆◆◆ = high

Source: Adapted from Barbier (1989a and 1989b).

3.3 Stage three: defining data collection methods and valuation techniques required for the economic appraisal

The final stage involves carrying out the actual assessment itself. Priority should obviously be given to assessing those resources, functions and attributes with the highest ranking. However, resource constraints, e.g., time, finances and skills, will also affect which characteristics can be valued and with what degree of accuracy. A resource, function or characteristic may initially be given a high ranking, but resource constraints may in fact prevent its valuation.

Resource constraints will also determine which data collection methods are appropriate and how they are implemented. For example, suppose it is important to value the watershed protection function of a wetlands area. If resource constraints are binding, it may be first necessary to determine what hydrological and ecological work has been previously conducted in the watershed that would assist the valuation. If information from previous studies is not sufficient, it may be necessary to conduct selective experimental studies of water flow and sedimentation rates in different parts of the watershed under varying degrees of wetland cover. At some point it may be necessary to employ geographical information systems (GIS) and other techniques to model the observed effects and the implications of disturbances to the watershed protection function.

Resource constraints and data collection options will influence the choice of *valuation techniques* to be selected. Although it is beyond the scope of these guidelines to provide a detailed description of all the methods that economists apply to value environmental goods and services, Figure 3.2 summarizes the general techniques available for assessing different wetland values.[13] Appendix 3 briefly outlines the advantages and disadvantages of the various techniques.

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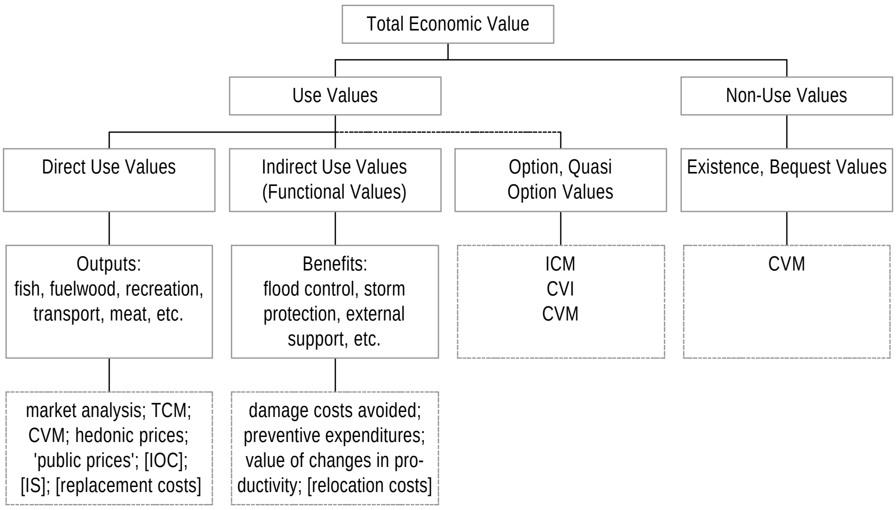
13 For detailed discussion of applications of valuation techniques to the environment, see Freeman (1993), Hufschmidt *et al.* (1983), and Johansson (1993).

As indicated in Chapter 2, applying valuation techniques requires an understanding of the economic concept of *willingness to pay* (WTP), which is the basis for economic valuation of any good or service. In a competitive economy, with no distortions to the price mechanism, one can assume that market prices reflect the willingness to pay for goods and services. For those direct use values which primarily involve harvesting of wetland resources, market prices should serve adequately as measures of value. However, two complications can arise in conjunction with the use of market prices for this purpose.

First, market prices may be distorted by deliberate interventions or imperfect competition, such as the existence of exchange rate controls (often a problem in developing countries), price ceilings or supports (especially in the agricultural sector), subsidies or taxes, monopoly conditions, etc. In such instances, *shadow prices* are often advocated. These are actual prices ‘adjusted’ to eliminate any distortions caused by policies or market imperfections so as to reflect true willingness to pay. However, one should be cautious in using shadow prices in place of market prices.

As noted in Chapter 2, a second complication is that many wetland values are not directly reflected in market prices at all. This is true for all the environmental functions, for resources harvested for own use by households, for most recreation and water transport services, and for all non-use values. In some cases, techniques such as the travel cost method, contingent valuation and hedonic pricing might be employed to estimate directly willingness to pay. As noted above, however, these more sophisticated techniques may be more suitable for temperate wetlands than for tropical wetlands.

Figure 3.2 Wetland valuation techniques



Source: adapted from Barbier (1989a)

Such valuation methods are not easily applicable in remote and rural settings in developing countries. In certain circumstances the analyst may have to use other valuation techniques, such as indirect substitute, indirect opportunity cost, relocation costs and replacement costs methods, which do not relate uniquely to willingness to pay. For example, some non-market values can be approximated through use of *surrogate market prices*, which is the use of an actual market price of a related good or service to value the wetland use that is non-marketed. In the case of harvested or directly used wetland resources that are not marketed (e.g., fuelwood), the value of their use can be estimated by the market price of similar goods (e.g., fuelwood purchased from other areas) or of the next best alternative or substitute good (e.g., kerosene or charcoal). If there is apparently no marketed substitute or alternative, then other methods of valuing a non-marketed wetland resource may have to be employed. One method is the *indirect opportunity cost* approach, where the time spent collecting or harvesting is valued in terms of foregone rural wages – the opportunity cost of labour based on other employment. Another method is the *indirect substitute* approach, where the opportunity cost of using a substitute for the wetland resource is employed as its value measure. For example, the opportunity cost of using dung that is normally applied as fertiliser as a substitute for fuelwood could be used to value the fuelwood, or the costs of obtaining water from outside the wetlands could be costed as a substitute for using the wetland as a source.

The actual expenditures on directly-used wetland services (e.g., recreation/tourism, water transport) may not reflect individuals' willingness to pay for them since they may be non-marketed and therefore unpriced inputs. If this is the case, alternative methods of valuation may be required. For water transport, the value can be expressed in terms of the *cost of alternative/substitute means* of transport. For recreation/tourism, the *travel cost method* may be applied, where the value of visiting wetland areas is derived from the cost of travel, including recognition of the opportunity costs of travel time.

Box 3.8 Contingent valuation: the blue ribbon panel's guidelines

The contingent valuation method (CVM) has been the subject of much debate, largely revolving around potential biases inherent in the technique and the controversial nature of the non-use values to which it has been applied. Recently, a 'blue ribbon' panel deliberated over the validity of CVM and cautiously ruled in favour of its limited use in such circumstances as judicial proceedings involving natural resource damages, but only if a series of guidelines were followed (Arrow *et al.*, 1993). The guidelines are the following:

1. For a single dichotomous choice question (yes-no type) format, a total sample size of at least 1000 respondents is required. Clustering and stratification should be accounted for and tests for interviewer and wording biases are needed.
2. High non-response rates would render the survey unreliable.
3. Face-to-face interviewing is likely to yield the most reliable results.
4. Full reporting of data and questionnaires is required for good practice.
5. Pilot surveying and pretesting are essential elements in any CVM study.
6. A conservative design more likely to underestimate willingness-to-pay is preferred to one likely to overestimate willingness-to-pay.
7. A willingness-to-pay format is preferred.
8. The valuation question should be posed as a vote on a referendum, i.e., a dichotomous choice question related to the payment of a particular level of taxation.
9. Accurate information on the valuation situation must be presented to respondents, with particular care required over the use of photographs.
10. Respondents must be reminded of the status of any undamaged possible substitute commodities.
11. Time-dependent measurement noise should be reduced by averaging across independently-drawn samples taken at different points in time.
12. A 'no-answer' option should be explicitly allowed in addition to the 'yes' and 'no' vote options on the main valuation question.
13. Yes and no responses should be followed up by the open-ended question: 'why did you vote yes or no?'.
14. On cross-tabulations, the survey should include a variety of other questions that help to interpret the responses to the primary valuation question, i.e., income, distance to the site, prior knowledge of the site, etc.
15. Respondents must be reminded of alternative expenditure possibilities, especially when 'warm glow' effects are likely to be present (i.e., purchase of moral satisfaction through the act of charitable giving).

Source: adapted from Bateman *et al.* (1993)

More often, the *contingent valuation method (CVM)* has been used to value recreation involving temperate wetlands. Contingent valuation is a survey technique using direct questioning of individuals while they are on-site or by mail to generate estimates of individuals' willingness to pay for something they value – in this case it would be improved recreation opportunities or simply maintaining existing recreation opportunities. Alternatively, individuals might be asked how much compensation they would require if they no longer had access to the wetland for recreation. Several case studies detailed in Chapter 4 make use of the contingent valuation methodology, but despite its wide use, it remains a somewhat controversial technique, in part because of the controversial nature of non-use values themselves, which it is often used to measure (see Box 3.8).

The values of wetland environmental functions arise indirectly through their support or protection of economic activity and property. Where economic production is being supported, the value of these functions can be measured in terms of the *value of changes in productivity* attributed to these functions operating normally. Where economic activity or property is being protected, the values can be expressed in terms of *preventive expenditures* that would be required if the functions were degraded or irrevocably disrupted, the *damage costs avoided* where these functions continue to function normally, the *costs of alternatives/substitutes* to replace these functions, or the relocation costs required if these functions were lost. For example, one case study examined in Chapter 4 includes an assessment of hurricane damages avoided by maintaining coastal wetland strips to reduce storm intensity inland (Costanza *et al*, 1989).

Estimating non-use values is extremely difficult unless use is made of such techniques as contingent valuation (CVM). The general approach is similar to that described above for recreation, and involves ascertaining from the individual either how much he or she is willing to pay to ensure that the wetland attributes are preserved, or alternatively, how much he or she is willing to accept in compensation for the loss of some or all of these wetland attributes. Hanley and Craig (1991) and Bateman *et al* (1995) use contingent valuation in an attempt to assess non-use values associated with two UK wetlands. In both cases, practical difficulties with capturing pure non-use values were encountered.

Any option value associated with preservation will also be difficult to assess and quantify. The general presumption is that the option values (including *quasi-option value*) attached to the majority of especially tropical wetlands may be very high, as they represent unique and irreplaceable assets that generate significant environmental benefits. The full value of these benefits may not always be realised currently, but may only become apparent as these wetlands are preserved over time. But precisely because option values arise out of the uncertainty over future unknown wetland benefits, they are extremely difficult to estimate.

A further consideration is whether current uses of a wetland are sustainable. Direct uses of a wetland area, such as harvesting for fish and timber, may significantly affect ecological relationships in the long term. Such tradeoffs between current direct uses and the long-run sustainability of important environmental functions may not be readily apparent. Thus, some attention must be paid to determining the 'sustainable yield' of wetland resources with regard to current direct uses. Where it is apparent that current harvesting or exploitation levels exceed the sustainable yield of wetland resources, this must be taken into account in the analysis. There are currently two approaches for doing this. The first would be to incorporate an *alternative sustainability scenario* in the evaluation and conduct a comparative analysis. If the comparative analysis reveals that the alternative sustainability scenario yields higher social returns than the current use scenario, then clearly the former is socially more optimal. The second approach would be to incorporate within a 'portfolio' of projects at least one *environmentally compensating project* to ameliorate the environmental degradation generated by other projects, thus ensuring overall sustainability of natural systems (Barbier, Markandya and Pearce, 1990).

4. Valuation in practice

The previous chapter provides an overall assessment framework for the economic valuation of wetlands. However, to illustrate the role of economic valuation in wetland management decisions as well as the application of specific valuation techniques, it is always instructive to explore a few case study examples. This is the purpose of this chapter. The studies selected are intended to present a range of wetland types, geographical regions, policy problems and valuation techniques. From temperate regions there are case studies from the prairie potholes of North America and peat bogs or mires of Northern Europe, as well as from the extensive marshlands of East Anglia in the UK. The subtropical coastal wetlands of the Southeastern US (Louisiana) are also considered. Tropical floodplain and coastal mangrove wetlands are represented from both Africa and Southeast Asia. For a much more extensive review of wetland valuation studies, see Gren and Södergvist (1994).

Various policy problems and appraisal methodologies are also included. These range from assessments of whether to convert wetlands to alternative uses, involving partial analysis, to the valuation of particular wetland functions (e.g., nitrogen abatement) as an element in a broader planning exercise. Efforts more closely resembling total valuation, in which an attempt is made to value *all* functions of a wetland, are also represented. One case study, an assessment of mangrove conversion in Indonesia, takes a more innovative approach to the policy problem at hand, in light of the poor data concerning links between the ecological and economic systems concerned.

Finally, there is a selection of valuation techniques represented, beginning with the more straightforward use of market price data, together with information about changes in productivity stemming from modifications to a wetland area. More sophisticated techniques, such as the integrated modelling of hydrological and economic systems, are presented for the assessment of complex ecological functions, such as nitrogen abatement. Contingent valuation, which involves the direct measurement of willingness to pay values, is also well represented, particularly in the temperate wetlands case studies.

4.1 The Hadejia-Nguru floodplain in Northern Nigeria

In northeast Nigeria, an extensive floodplain has been created where the Hadejia and Jama'are rivers combine to form the Komadugu-Yobe river which drains into Lake Chad. Although referred to as the Hadejia-Nguru wetlands, after the two principal towns in the area, much of the floodplain is dry for some or all of the year. In recent years, the maximum extent of flooding has ranged from 70,000 to 90,000 hectares due to upstream developments and droughts, but it once extended over 300,000 ha (Hollis *et al.*, 1993). Barbier *et al.* (1993) conducted a partial valuation to assess the economic importance of the Hadejia-Nguru wetlands, and thus the opportunity cost to Nigeria of its loss. The authors estimated some of the key direct use values the floodplain provides to local populations through exploitation of its resources.

The Hadejia-Nguru wetlands provide essential income and nutrition benefits in the form of agriculture, grazing resources, non-timber forest products, fuelwood and fishing for local populations. The wetlands also serve wider regional economic purposes, such as providing dry-season grazing for semi-nomadic pastoralists, agricultural surpluses for neighbouring states, groundwater recharge of the Chad Formation aquifer and 'insurance' resources in times of drought. In addition, the wetlands are a unique habitat for migratory waterfowl, especially wader species from Palaearctic regions, and contain a number of forestry reserves. The region therefore has important tourism, educational and scientific potential.

Water is the limiting resource for development in the region. In recent decades the Hadejia-Nguru wetlands have come under increasing pressure from drought and water resource schemes. The storage of water in upstream dams, which is diverted for irrigation, has reduced the size of flood flows into the wetlands. In addition, increased demand for irrigation water for agriculture downstream of the wetlands may lead to diverting water past the wetlands through construction of bypass channels. Intensified human use within the floodplain itself is also putting pressure on the wetlands.

These developments are taking place without consideration of their impacts on the Hadejia-Nguru wetlands or any subsequent loss of economic benefits that are currently provided by use of the floodplain. Water diverted to upstream and downstream uses clearly has an 'opportunity cost' in the form of the various wetland benefits provided by the floodplain. Upstream and downstream developments should not proceed unless it can be demonstrated that the net benefits gained from these developments exceed the net benefits foregone through wetland loss in the Hadejia-Jama'are floodplain.

A partial valuation was conducted to assess the economic importance of the Hadejia-Nguru wetlands, and thus the opportunity cost to Nigeria of its loss, by estimating some of the key direct use values which the floodplain provides to local populations through crop production, fuelwood and fishing. The economic analysis indicates that these benefits are substantial on both a per hectare basis and a water input basis – i.e., the minimum and maximum amount of floodwater required to sustain them. This proves to be the case even when the agricultural benefits are adjusted to take into account the unsustainability of much pump-irrigated wheat production within the wetlands. As indicated in Table 4.1 below, the present value of the aggregate stream of agricultural, fishing and fuelwood benefits were estimated to be around N253 to N381 per hectare (US$ 34 to 51), or around N72 to N109 (US$ 10 to 15) per $10^3 m^3$ (1989/90 prices based on the maximum flood inputs).

The economic importance of the wetlands means that there will be an economic loss (an opportunity cost) associated with any scheme that leads to degradation of the floodplain system, e.g., by diverting water away from them. When compared to the net economic benefits of the Kano River Project, the economic returns to the floodplain appear much more favourable (see Table 4.1). This is particularly the case when the relative returns to the Project, in terms of water input use, are compared to those of the floodplain system. The result should cause some concern, given that the existing and planned water-related developments along the Hadejia-Jama'are river system, such as the Kano River Project, will continue diverting water from the floodplain.

Table 4.1 Comparison of present value of net economic benefits, Kano River Project and Hadejia-Nguru Wetlands, Nigeria[a/]

discount rate period	8% 50 years	8% 30 years	12% 50 years	12% 30 years
1. Total (N'000) b/				
wetlands	278,127	256,340	190,013	184,446
Kano River Project	4,451	4,096	3,022	2,931
2. Per Hectare (N/ha) c/				
wetlands	381	351	260	253
Kano River Project	233	214	158	153
3. Per Water use (N/m^3) d/				
wetlands	109,112	100,565	74,544	72,360
Kano River Project	0.3	0.3	201	195

Source: Barbier, Adams and Kimmage (1993)

Notes:
a/ 7.5 Naira = US$ 1.00 (1989/1990 prices)
b/ Based on a total net benefit from agriculture, fuelwood and fish production attributed to the Hadejia-Nguru wetlands and total net benefits of irrigated crop production from the Kano River Project
c/ Based on 230,000 hectare cropland, 400,000 hectare forest and 100,000 hectare fishing and total production area of 730,000 hectare for Hadejia-Nguru wetlands and a total crop cultivated area of 19,017 hectare in 1985/86 for the Kano River Project.
d/ Assumes an annual average flow into the wetlands of 2549 Mm^3, annual water use of 15 $10^3 m^3$ per hectare for the Kano River Project.

Moreover, as noted above, there are other significant economic benefits provided by the floodplain system than the ones estimated in the analysis. The sum total of these additional benefits may actually exceed the estimated returns to floodplain agriculture, fishing and fuelwood. Perhaps the most important environmental function of the Hadejia-Nguru wetlands is its role in recharging the groundwater aquifer of the Chad Formation. Evidence presented by Hollis *et al* (1993) shows that a reduction in floodplain inundation leads to a lower rate of groundwater recharge. Since 1983, when the extent of flooding dropped appreciably, groundwater recharge fell by an estimated aggregate amount of 5000 $10^9 m^3$. Continual loss of groundwater storage and recharge will have a significant impact on the numerous small villages throughout the region that depend on well water from the aquifer for domestic use and agricultural activities. Valuation of these impacts is difficult but could be accomplished through direct or indirect measures of villagers' willingness to pay for water.

In sum, the economic importance of the Hadejia-Nguru wetlands suggests that the benefits they provide cannot be excluded as an opportunity cost of any scheme that diverts water away from the floodplain system. The analysis indicates that there may be scope for the design and operation of upstream dams to produce an artificial flood regime, as suggested by Hollis *et al* (1994). The net present value of the economic benefits associated with this option would range from N375 to 565 (US$ 50-75) per 1000 m^3 of water released (including an adjustment for unsustainable wheat cultivation), compared with N242 to 366 (US$ 32-49) per 1000 m^3 under average annual flows from 1985-87, which were 38% higher than the estimated requirement for a controlled release. The latter figures coincide with the estimates provided on a per hectare basis in Table 4.1. Although a regime of controlled releases may be insufficient to maintain groundwater recharge at present levels, the regime would provide the minimum amount of water required to sustain floodplain agricultural, fishing and fuelwood benefits.

4.2 Valuing prairie wetlands in North America: application of a bioeconomic model

The rolling prairies of western North America contain millions of small potholes which are crucial for the rearing and staging of migratory waterfowl. Although this region contains only 10% of the total continental breeding area for waterfowl, it has historically accounted for about 55% of duck ‘production’. Waterfowl are valued not only by non-consumptive recreationists (e.g., bird-watchers) but by hunters, and may provide additional ecological values as well. For example, Canadian government estimates from the early 1980s placed the net value of waterfowl to Canadians at C$ 118 million (US$ 100 million) per year (Environment Canada, 1982). Prairie wetlands support these recreational activities and other waterfowl values by providing habitat for their breeding and other life cycle activities.

At the same time, most potholes are located on privately-held farmland. Faced with pressure to drain and convert these lands to agricultural production, the question arises of allocating these wetland resources to their best use. Hammack and Brown (1974) attempted to value prairie potholes in their alternative uses, or what amounts to a partial analysis of a wetland problem, and then to estimate the optimal numbers of potholes to conserve. Their approach has come to be known as a *bioeconomic model* because it combines both economic and biological/ecological relationships in a single optimisation model.

Hammack and Brown began by valuing waterfowl as an input to satisfying recreational hunting demand.[14] To accomplish this they

14 Non-consumptive recreational activities associated with waterfowl were ignored since the marginal changes in population numbers implied by the analysis were thought to have little impact on birdwatching opportunities. Subsequent declines in waterfowl numbers across the continent would require re-examination of this assumption if the study were to be repeated now. A second assumption implicit in the analysis is the critical role of summer breeding areas in controlling population numbers. Again, a re-examination of the situation with wintering habitat in the southern US, Central and South

undertook a contingent valuation survey of recreational hunters in seven western states, using a mailed questionnaire. Their intent was to show that hunters value additional waterfowl 'kills' beyond their current harvest, indicating that any policy action which increases the number of waterfowl in the fall (autumn) flight would generate hunting benefits. They further wanted to demonstrate that such increases could be related to changes in the availability of breeding habitat (e.g., prairie potholes). By approaching the problem in this way, Hammack and Brown would then be able to derive the underlying value of the wetlands as duck 'factories'. That they should have difficulty obtaining a value for prairie wetlands in their natural state simply reflects the non-market nature of many wetland-related recreation benefits and the indirect way in which these benefits are generated. Complicating things further, the harvesting of waterfowl occurs at a distance from the breeding sites, so that the link between decisions made by the farmers who own the pothole land and waterfowl hunters are not at first obvious. By extension, such a situation has ramifications for the distribution of the costs and benefits of preserving prairie wetlands which must also be addressed, including the transnational nature of the problem.[15]

The results of their contingent valuation study suggested that hunters do indeed value the bagging of extra waterfowl, with estimated values ranging from just over US$ 2 to just over US$ 5 per additional bird (1968/69 prices). This information was later used to link hunter values with the physical productivity of prairie wetlands as waterfowl breeding habitat. First, the production dynamics of migratory waterfowl required investigation. Quantifying the physical production relationship requires tying the

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America, in light of land use changes since the mid-70s, might result in a rethinking of this assumption.

15 To a large extent this skewness in the distribution of costs and benefits was addressed by the signing of the North American Waterfowl Management Plan by all three North American governments. However, the Hammack and Brown study predates much of the work leading up to this agreement and does not, in fact, explicitly recognize the transnational issue, which stems from a disproportionately large number of ducks produced in Canada but relatively few actually harvested there.

supply of breeding habitat with production of waterfowl offspring. Equations estimating historic population data as a function of annual numbers of potholes provided the necessary relationships, and, in fact, a surprisingly strong link was established, considering the multitude of additional factors which might be expected to play a role in determining annual production of young. These results were then combined with information about waterfowl mortality to provide a model which described changes in wetland area in terms of their impact on numbers of birds in the fall flight, which is the variable of direct interest to hunters.

As noted above, maintaining prairie wetlands in their natural or semi-natural state involves a cost, as they have an alternative use as cultivated land. Even though these wetlands are marginal as agricultural land, once drainage costs are considered, farmers may still find an incentive to convert them, particularly if they cannot 'capture' duck production and hunting benefits unless hunters actually pay to use their land for the latter purpose. Hammack and Brown considered two approaches to valuing prairie wetlands as agricultural land: a review of payments to farmers to set such land aside in its natural state and an assessment of the potential net returns from pothole land once drained. They found a range of $US 1 to 17 per pothole but, to be conservative, settled on the latter value and considered a slightly lower value of $US 12 per pothole as an alternative case.

Once one has obtained quantified values for additional waterfowl, the productivity of potholes in terms of duck production, and the opportunity costs of setting pothole land aside in its natural state, these figures can be combined within the bioeconomic model framework. The need to use a more complex optimisation framework arises because the problem at hand is continental in scope and not one of a simple either/or decision, as might characterise a conversion proposal for a single site.

The objective of the bioeconomic model is therefore to determine the optimal number of pothole sites to preserve under 'steady state' conditions (i.e., assuming the dynamic model used settles down to such a 'steady state'). Arriving at a solution to the problem requires balancing the net benefits of preserving potholes, indicated by the additional numbers of birds present in the fall flight and incremental hunting values associated with 'bagging' a share of these, against the net benefits of converting these potholes to marginal agricultural land, taking due account of the costs of drainage. Ideally, the saved costs from no longer having to work around the potholes when cultivating should also be considered, but this was not included in the analysis. Optimal results for the annual number of breeders, number of ponds, marginal value of a waterfowl and total 'kill' under differing modelling assumptions are shown below.

The results (Table 4.2) suggest that the historical numbers of prairie ponds, breeding waterfowl and waterfowl bagged have been well below the optimal number. This finding accords with the notion that important wetland benefits have not been taken into account when choosing to convert these wetlands to an alternative use, and therefore too many potholes have been drained. If wetlands of the prairie pothole type were irreversibly lost once converted, and could not be replaced, then the analysis would suggest stopping all drainage now to avoid further losses, but achieving any sort of optimum would be foregone since increasing the supply of wetlands would not be possible.

However, prairie wetlands can to some extent be restored, or new areas can be developed at alternative sites to 'replace' those lost elsewhere, suggesting that policies to encourage creation of wetlands should pay handsomely. Recognising these potential benefits, conservation groups such as Ducks Unlimited have engaged in just this sort of activity, supported primarily by American hunters and using the funds collected to assist farmers with maintaining their wetlands. This privately-initiated conservation activity has helped bridge the gap between farmers faced with the opportunity cost of preserving prairie wetlands and the hunters benefiting from this activity.

One result missing from the Hammack and Brown study is that the hunting-related value attributable to the wetlands is not isolated (except for a rough calculation not related to the authors' model).

Instead, the focus is directed towards valuing waterfowl, which can be described as an 'output' of the wetlands, but an 'input' providing satisfaction to hunters. Valuing the wetlands themselves would require backtracking a step further to derive the value of wetlands as input into producing waterfowl. Solution of the model implies that ponds should be preserved as long as the number of additional ducks produced, multiplied by their value to hunters, at least equals their alternative value as agricultural land. Thus, the productivity of the wetlands preserved in the optimal solutions indicated above would at least equal US$ 12 to 17, depending on the pond cost scenario considered. Additional reinterpretation of the results would be necessary to estimate a proper 'welfare measure' of wetlands value.

The Hammack and Brown study demonstrates the usefulness of combining economic and biological information within a common modelling framework and applying this to a wetlands conversion problem. Despite the limitations of the data, and the need to fill gaps with assumptions or extrapolate from regional information, the analysis provides clear evidence of the undervaluing of an important continental wetland resource. Subsequent work by other economists has shown the role of governments in fostering wetland conservation through 'set aside' programmes (van Kooten and Schmitz, 1992, Heimlich, 1994, Parks and Kramer, 1995), as well as the contradictory incentives created by governments which provide incentives to drain wetlands to encourage agricultural output expansion. In some cases, both incentives have existed side-by-side.

Table 4.2 Bioeconomic model results for prairie wetlands and Mallard ducks

(Units are millions unless otherwise indicated)

	Historical Values 1961-68	Model Results Ponds at US$ 12 a/	Model Results Ponds at US$ 17 b/
Number of Breeders	7.8	12.1 - 17.2	9.5 - 11.4
Number of Ponds	1.3	2.9 - 7.5	2.0 - 4.2
Value of Additional Waterfowl ($US per waterfowl 1968/9 prices)		2.40 - 4.00	3.40 - 4.65
Total Waterfowl Bagged	3.7	8.1 - 19.2	6.2 - 10.6
Waterfowl Bagged per Hunter (waterfowl/ hunter) c/	3.5	4.7 - 11.2	3.6 - 6.2

Source: Hammack and Brown (1974)

Notes: a/ Results are for mallards only, which represented about 30% of waterfowl bagged, and Pacific Flyway data, but extrapolated to the continental population.

b/ Ranges shown reflect the three different biological production models used; 8% discount rate used.

c/ Figures are for the Pacific Flyway only; historical figure is for 1965-69.

4.3 Contingent valuation and wetlands in the UK

The UK is characterised by several extensive wetland areas. Two of the most important are the Norfolk Broads in East Anglia and the blanket peat bogs of the Scottish ‘Flow’ Country. Both areas have been subjected to economic valuation studies to assess the merits of retaining wetland areas *versus* permitting them to be converted to alternative uses or simply to degrade from lack of investment in management and control works (Bateman *et al.*, 1993; Bateman *et al.*, 1995; Hanley and Craig, 1991). The Norfolk Broad study is discussed first, followed by a summary of the Scottish Flow Country analysis.

The Norfolk Broads constitute a sizeable wetland complex which supports various agricultural activities, such as cropping and grazing, and recreational or amenity opportunities of national significance. Nutrient retention is also an important service provided by the Broads, and the area is an important habitat for numerous species of waterfowl and other fauna. Since the wetlands are of national interest, they might be expected to generate not only important use values but significant non-use values as well. The area has historically been associated with peat extraction and has been subjected to drainage, channelization of watercourses and substantial dyking and flood control works, portions of the latter having been allowed to degrade so that saline flooding is a substantial threat. In recent years, it has been recognized that the area could not continue to provide the same level of outputs and services without some attention to improved management and resolution of key resource conflicts. To protect the integrity of the area, a number of alternatives have been proposed, including the strengthening of flood walls and construction of a tidal barrier.

To assess the merits of investing in these improvements, a cost-benefit analysis was undertaken. However, as discussed in Chapter 2, key services provided by a wetland are liable to be difficult to quantify, as are any non-use or existence values associated with the site. In particular, the important recreational use values associated with the Broads are not subject to a market and therefore go unpriced. Various valuation options exist for eliciting recreational values, including the travel cost method and the contingent valuation method. In the case of the Broads, a contingent valuation study was undertaken to determine the willingness-to-pay to conserve these recreational benefits via the proposed protection strategy. In addition, a contingent valuation study of non-use values was also undertaken. As the ultimate aim of a cost-benefit analysis is to assess the full net benefits of investing in wetland improvement, the study can be considered within the broad framework of a total valuation. However, only the estimates for recreational and non-use values are reported here.

The study's authors went to considerable trouble to avoid many of the potential difficulties of applying the contingent valuation approach, particularly when assessing recreational values (the study of non-use values is discussed separately below). For example, the study attempted to incorporate a number of different questioning techniques and adhered to a recently-developed set of rules governing the use of contingent valuation (see Box 3.8). Surveying was performed on-site and involved a large sample size (about 3000). Considerable care was also taken to ensure that a constant flow of information was provided, in order to avoid bias associated with the level of knowledge of each respondent. As a result, the Broads study represents a good example of the application of direct survey or valuation techniques to a wetlands problem.

Table 4.3 Recreational and amenity use value estimates for the Norfolk Broads, East Anglia (1991 £)[a]

Question Format	No. of Respondents	Mean WTP	Min bid	Max bid
Open-ended Question	846	67	0	1250
Iterative Bidding Question	2051	75	0	2500
Dichotomous Choice Question	2070	140	-	-

Source: Gren *et al.* (1994)

a/ Values can be compared to US$ using an exchange rate of £0.567 = US$ 1.00

Of particular interest is the use of three different question formats to elicit the willingness-to-pay responses for maintaining the wetland area in its present condition. All formats used an increase in taxes as the 'vehicle' for collection of the hypothetical payments. One technique involved an open-ended question, which simply asked the respondent how much he or she would be prepared to pay annually to conserve the area. A second question format used an ‘iterative bidding’ approach, providing the respondent with a range of values to choose from and asking him or her to select one. The third technique is referred to as a ‘dichotomous choice’ format because it involved a yes or no answer to a predetermined figure, which may be varied from individual to individual. This information is then used to determine the respondents’ probability of choosing a particular value. Dicho-tomous choice has become a more popular format in recent times because of its supposed advantages over other techniques with respect to bias problems.[16] Results for the three question formats are presented in Table 4.3.

To complete a full cost-benefit analysis of protecting the Broads involves assessment of other values associated with the wetlands in addition to those ‘captured’ by the on-site CVM survey. These values include other direct uses, perhaps some indirect uses, and any non-use values associated with the site Only the latter are considered further here, as an attempt was made to assess these using a contingent valuation approach in a study related to the recreation one reported just above.

To try to capture the non-use values related to conserving the Norfolk Broads, Bateman *et al.* (1995) undertook a mail survey across the UK. Information collected included both background socioeconomic data and distance from the site.

Unfortunately, the study was not able fully to distinguish nonusers from past users, so the results must be interpreted with caution and may not properly constitute existence or non-use willingness-to-pay. Nonetheless, the values obtained are instructive. For example, the results demonstrate a significant ‘decay factor’; that is, values tend to decline as the respondent’s distance from the area increases. For households located in a zone closer to the wetlands, an average willingness to pay of £12.45 (US$ 22) per household was elicited, compared with a figure of £4.08 (US$ 7.2) for households elsewhere in the UK. Aggregate estimates of

16 See Mitchell and Carson (1989) for a more detailed description of the bias problems inherent in CVM.

willingness-to-pay of £32.5 million (US$ 57.3 million) and £7.3 million (US$ 12.9 million), respectively, were calculated.

From the Norfolk Broads of Southern England we shift to the peat bogs of Northern Scotland. Hanley and Craig (1991) conducted a partial valuation of alternative uses of peat bog in Northern Scotland's 'Flow Country'. This large area of blanket peat bog, covering over 400,000 hectares, has many unique plants and is important as bird habitat. It has been subjected to conversion through planting of pine and spruce in block plantations, resulting in damage from habitat disturbance, disruption of water and soil regimes, increased sedimentation and erosion. In assessing the tradeoffs, the authors conducted a partial analysis to compare the option of conserving the bog areas in their current state against converting them to block plantations. An important consideration is the role of government incentives in stimulating the planting of trees.

The researchers calculated the net benefits of tree planting by determining the profits from an infinite cutting and replanting rotation. Gross revenues from each clear-felling amount to £5,921 (US$ 10,517) per hectare (1990 prices), and these were then combined with initial establishment and replanting costs and a 6% discount rate. As this was an economic analysis, concerned with assessing the full costs and benefits to the nation, no account was taken of any subsidies provided under government tree-planting support programmes. The resulting net present value was negative, at minus £895 (US$ 1590) per hectare, indicating that without government support there would be little interest in planting trees as a commercial undertaking, regardless of any environmental tradeoffs. This result was unchanged even when land was assumed to be available free of charge for tree planting.

Negative returns from tree planting indicate that conserving the flow country in its natural state is undoubtedly the preferred land use option. Thus, it might be argued that further evaluation of benefits of conserving the area is not required. Nonetheless, the researchers proceeded with valuation of the alternative of maintaining the flow country in its present state to reinforce the conclusion that conserving the area is optimal. To determine the values associated with a conservation option, the researchers conducted a contingent valuation survey.

The contingent valuation survey in this case was aimed at assessing regional residents' willingness-to-pay for conserving the area by asking whether they would be willing to contribute a one-time amount to a trust fund established to conserve the area. Setting up a contingent valuation questionnaire in this way allows the researcher to capture a wide range of use and non-use values, between which the questionnaire attempted to differentiate by asking individuals whether they had visited the site previously. While this approach distinguishes historical users from nonusers, it does not isolate option values from non-use values, since some current nonusers may harbour an interest in visiting the area in the future. Where the latter is true, then such values should be properly classed as a use value and not a non-use value. Thus, the estimates for non-use values estimated from the survey results may capture some unknown amount of (potential) use value.

Of 400 questionnaires posted out, 159 were returned and 129 of these were usable. Of these 129, 78 stated a positive willingness to pay, 22 were zero values and there were 29 'protest' bids (i.e., responses which indicate an arbitrarily low or high value to express opposition to the process or subject matter of the questionnaire). The mean willingness-to-pay was estimated at £16.79 (US$ 30) per household, but values varied according to whether the respondent had visited the site. Those who had visited expressed a higher willingness-to-pay, averaging £24.59 (US$ 43.70), while non-visitors offered an average of £12.15 (US$ 21.60).

By extrapolating the average willingness-to-pay over the entire regional population, and expressing this on a per hectare basis, the net present value of conserving the area could be estimated. The researchers arrived at a figure of £327 (US$ 580) per hectare, which contrasts with the negative figure of minus £895 (US$ 1590) per hectare calculated for converting bog areas to block plantations. Alternatively, the net present value of converting the area to plantations could be expressed as minus £1222 (US$ 2170) per hectare, by adding the two values, which would reflect the true net benefits of converting the area, inclusive of lost preservation values.

The two UK studies presented above demonstrate the substantial values associated with conserving temperate wetlands with high recreational use but relatively low uniqueness (e.g., Norfolk Broads) or with low recreational use but a high level of unique fauna and flora (e.g., Scottish Flow Country). The studies also highlight the possibility of using contingent valuation as a tool for valuing wetland benefits, especially where these are difficult to quantify using other techniques. While the estimated values relating to direct uses seem plausible, in both cases there were obstacles to obtaining a credible estimate of non-use value. Improvements in the design and application of contingent valuation studies may eventually overcome these difficulties, but in the meantime, caution must be advised if assessing non-use values is the objective. Nonetheless, contingent valuation remains the only method capable of at least theoretically measuring such values.

4.4 Valuing nitrogen abatement using Swedish wetlands

One of the ecological functions of certain wetlands is the retention and recycling of nitrogen carried in surface water flows. A study to assess the benefits associated with this service was conducted in Sweden and concerned options for reducing nitrate pollution in groundwater supplies on the island of Gotland (Gren, 1995)[17]. Abatement of nitrogen found in watercourses which eventually reach the sea also reduces coastal marine pollution, but this benefit was not considered. The valuation exercise here was a partial valuation of wetlands, since nitrogen abatement by wetlands was compared to alternative means such as reducing application of fertilisers and installation of additional sewage treatment facilities.

17 Several summaries of this research have been published, some differing in the values presented as a result of a different presentational focus (e.g., Gren *et al*, 1994). This case study is based upon the final published version (Gren, 1992) .

Some of the additional services provided by the Swedish wetlands were also valued along with the nitrogen abatement function. Modelling of these other functions drew on other valuation work undertaken by Folke (1990), who considered the broader 'life support' functions of Swedish wetlands, including water and energy (i.e., peat) supply and provision of habitat.

Nitrogen may originate from a number of sources, but in the Swedish case it arises chiefly as leachate from drained marshes and as non-point source pollution from the use of fertiliser and manure by farmers. Secondarily, nitrogen may originate from domestic sewage and be passed on to water systems in effluent released from sewage treatment plants. In the Gotland region, nitrate concentrations in some aquifers are about double the World Health Organization's (WHO) recommended safe concentration.

Valuing the nitrogen abatement service offered by wetlands requires several steps. First, the value associated with improved water quality must be established. This requires estimation of the willingness to pay for improved water quality as reflected in a lower concentration of nitrates. Second, reductions in nitrogen loadings in watercourses and lower concentrations of nitrate in groundwater must be linked quantitatively. Third, information about the nitrogen retention rates of wetlands is required in order to relate wetland area, the variable subject to policy control, to the reduced nitrogen loadings in existing surface waters. Finally, estimates of the additional services provided by wetlands must be made to complement the values associated with the nitrogen abatement function alone. Adding these values provides a more complete accounting of the benefits provided by wetlands when comparing this nitrogen abatement technique to other approaches.

A measure of the value attributed to improved water quality (i.e., reduced nitrate concentrations) was obtained from a contingent valuation survey of Swedish citizens. Respondents were informed about health risks associated with higher nitrate levels and then provided with information about per capita government expenditures in various sectors. The willingness-to-pay question asked how much they would be willing to pay in the form of a proportional tax to finance the suggested improvements in water quality. Providing government expenditure data was intended to provide a safeguard against unrealistically high valuations by allowing the individuals to compare their responses to current per capita expenditures in other sectors. The results of the contingent valuation survey indicated that average willingness to pay to reduce nitrate pollution to WHO-recommended levels was about SEK 600 (US$ 100) per person per year. An alternative case at half this level was also analysed.

Establishing the relationship between reduced nitrogen loadings in surface waters and improved water quality involved use of a hydrological model. Modelling of this process suggested that the relationship involving nitrogen loading in surface waters and nitrate concentration in groundwater is linear. Combining the valuation results for reduced nitrate in drinking water from the contingent valuation survey (and estimates of regional population) with the results from the hydrological model allows an estimate of the value associated with a reduction in the nitrogen content of surface waters. These values were SEK 1.4 (US$ 0.24) per kg N reduction for a willingness-to-pay of SEK 300 (US$ 50) per person per year, and SEK 2.7 (US$ 0.46) per kg N reduction for a willingness-to-pay of SEK 600 (US$ 100) per person per year (at 1990 prices).

The next step in the valuation process is to relate the values of reduced nitrogen loadings in surface waters to the absorptive capacity of wetlands, in order to express nitrogen abatement benefits on the basis of wetlands area. Swedish research suggests that the abatement capacity of a hectare of natural wetlands ranges from 100 to 500 kg N per year, with the actual figure depending upon local conditions. Since the intention of the nitrogen abatement programme would be to restore wetlands previously lost through conversion to agricultural use, consideration must be given to the nitrogen absorption potential of these rather than natural wetlands. The assumption adopted was that restored wetlands would eventually attain the upper figure in the range presented above, but only after a phasing-in period of ten years.

Taking account of the value of nitrogen reductions (SEK 1.4 and 2.7 per kg N reduction) together with the abatement capacity of wetlands, the author estimated the value of water quality improvements from investing in restoration of wetlands at SEK 200 (US$ 34) per kg N reduction. As measured here, this value should be seen as the benefit associated with an investment in abatement capacity rather than as a value per kilogram of nitrogen actually abated. Calculating the former requires consideration of the growth in abatement capacity over time as the restored wetland becomes established, calling for discounting procedures (these made use of a 3% discount rate).

Investing in wetlands to abate nitrogen pollution brings with it several additional benefits, as cited earlier, since the Gotland wetlands are multi-functional. Using data from Folke (1990) for a mature wetland, the Martebo mire (also on Gotland), values were extrapolated to restored wetlands on Gotland, not including the estimates for the nitrogen abatement benefits calculated for Martebo. Valuing these additional wetland functions involved use of the replacement cost technique (see Appendix 3), such as estimating the costs of replacing water supplies derived from the wetland with additional investments in drinking water supply. Together, the value of the wetland functions considered (e.g., water supply, energy production from peat, and provision of habitat) was calculated at SEK 1000 (US$ 169) per year. Placing this value on an equivalent basis with water quality improvements again involves discounting, resulting in a final value of SEK 147 per kg N reduction capacity.

A final consideration in valuing the Gotland wetlands was the impact of wetland restoration on the economy at large. Investments in wetlands entail costs for labour and other inputs and these can be expected to have beneficial income effects, which in a full economic analysis should be taken into account. This consideration may be especially important where alternative policy actions are being assessed, and the options involve quite different impacts on the wider economy. As the investment activity required for wetlands restoration is limited, a relatively small value of SEK 2 (US$ 0.34) per kg N reduction capacity was derived using an economic model of the Gotland economy. Income effects were much more important for alternative means of reducing nitrogen, such as the expansion of sewage treatment plants.

Table 4.4 Values associated with nitrogen abatement in Gotland, Sweden (SEK/kg N reduction, 1990 prices)[a]/

Policy Option	Nitrogen abatement	Other wetland functions	Income effects	Total
Restoration of wetlands	200	147	2	349
Expansion of sewage treatment plants	54	n.a.	28	82
Reduction in the application of nitrogen fertilisers	2.7	n.a.	-	2.7

Source: Gren 1995

a/ SEK 5.918 = US$ 1.00

Table 4.4 brings together values associated with restoring wetlands for the purpose of nitrogen abatement, and compares these with parallel estimates for alternative nitrogen abatement measures. The details concerning these alternatives are not provided here but can be found in Gren (1992). Some care is required in interpreting the nitrogen abatement values in Table 4.4, since they involve some assumptions which are not immediately obvious. For example, the wetlands and sewage treatment options both involve creating a capacity for annual nitrogen abatement, whereas the fertiliser option refers to a one-time reduction in fertiliser and therefore involves a single year only. In addition, the differences in nitrogen abatement values for the wetlands and sewage treatment options result from assumptions about the trends in values over time. For the wetlands option, nitrogen abatement capacity is assumed to increase naturally over the first ten years after restoration, while sewage treatment capacity decays as a result of depreciation of the initial capital investment in plant expansion. Discounting annual values subjected to these time trends results in the divergence in values illustrated in Table 4.4. If there were no time trends to consider, values for the two options would be identical since they rely upon the same measurement of willingness-to-pay per kilogram of nitrogen reduction.

On the evidence provided above, it is apparent that restoring wetlands to abate nitrogen involves substantively higher benefits than either of the alternatives. The secondary benefits stemming from the restoration of wetlands are important elements in this observation. The low figure for reduced use of nitrogenous fertilisers stems from the non-investment nature of this option. Benefits are therefore directly linked to actual unit decreases in nitrogen rather than indirectly through investing in nitrogen abatement capacity. However, to draw more useful conclusions about which option is preferred requires the introduction of the costs of each nitrogen abatement approach.

Costs for restoring wetlands chiefly involve the opportunity costs of lost agricultural or other land use benefits, foregone when the land is turned back to its original wetland state. These opportunity costs are estimated at about SEK 2000 (US$ 338) per hectare, or SEK 93 (US$ 16) per kg N reduction capacity. Expansion costs for sewage treatment plants (to increase the efficiency of nitrogen extraction) range according to plant type and the depreciation rate selected, and are estimated at SEK 50 (US$ 8.40) to SEK 150 (US$ 25) per kg N reduction capacity. No costs are supplied in the study for reductions in fertiliser application, but these would presumably involve lost agricultural production.

Incorporating the costs of abatement under each option does not change the general picture emerging from examination of the benefits alone. The net benefits from wetland restoration clearly exceed those for sewage treatment plant expansion, with the latter incurring possible negative values for some plant types.

This study demonstrates the role that wetlands valuation can play in addressing important policy choices. Not only are wetlands valuable natural assets when left in their natural state to produce a range of useful outputs and services, but even restoring them can be a practical and efficient way of achieving important improvements in environmental quality. While numerous assumptions were made in undertaking the assessment of a complex wetland function, the large difference in the net benefits involved suggests that the results can be accepted with some degree of confidence. A highlight of the analysis is its use of an integrated ecological and economic approach to modelling the functions and values concerned.

4.5 Valuing coastal wetlands in the Southeast USA

Louisiana's coastal swamps constitute about 40% of the entire coastal wetland resources of the USA (Bergstrom *et al.*, 1990). As such, these wetlands are of great importance for the recreational, commercial harvest and ecological service benefits they provide. However, like wetlands virtually everywhere, they are under threat from competing uses and modifications internally or externally which affect their functioning, and wetland benefits are being lost as a result. Bergstrom *et al.* (1990) list the main factors which threaten the area as commercial development, navigation, saltwater intrusion and subsidence, and note that the rate of wetland loss is on the order of 104 to 155 km^2 per year (from Craig *et al.*, 1979).

The case study considered here involves an attempt to value several of the key direct and indirect uses of Louisiana's coastal wetlands, within a total valuation framework (Farber and Costanza, 1987; Costanza *et al.*, 1989). Rather than a situation involving a single conversion or modification threat, the problem is one of a more general nature, making the total valuation approach more appropriate. Moreover, the need to consider the full range of values associated with the wetlands area is even more obvious if decisions are to be made about the extent of the conservation effort which might be justified. Whereas estimates of the values associated with particular functions or direct uses of the coastal wetlands of Louisiana have been made previously, the study reported here is the first to try to aggregate these values for a single wetland system – in this case, the wetlands of Terrebonne Parish in the Mississippi Delta region of the state.

Costanza *et al.* were able to make credible estimates of four different use values, recognizing that there are many other important values which cannot be quantified because of insufficient data. The values they considered are commercial fishing catches of several different species, fur trapping, recreation and storm protection. Since these values differ enormously, measuring them called for a variety of valuation techniques. The remainder of the case study discusses the valuation procedures used and presents the individual and aggregate present values in Table 4.5.

Many species of fish and shellfish rely on the coastal wetlands for habitat support, and several of these are important commercially. Loss of wetlands has a negative impact on these species and results in lower sustainable catches. As with the analysis of nitrogen abatement services provided by Swedish wetlands, valuation of the habitat support offered by Louisiana's coastal wetlands requires linking ecological processes with the economic benefits associated with the commercial fish catch. This approach recognizes the role of marsh as an input into the production of fish and calls for modelling of the 'marginal productivity' of the marsh area with respect to production of fish biomass. The focus must be on the impact of small gains or losses of wetland area (thus, the term 'marginal'), rather than complete devastation, as this is the manner in which the modification or loss of wetlands is likely to occur.

Fortunately, the data are relatively good for Louisiana's coastal fishing industry, so that the ecological support provided by the marsh areas for several species can be estimated or the results from similar, nearby coastal areas can be adapted for the purpose. Annual marginal productivity figures for two species of shrimp were estimated by the researchers, and these range from 0.90 to 1.60 lb per acre. Combining these figures with ex-vessel prices provides a rough estimate of the value of the shrimp production benefits of coastal marsh (1983 prices), here valued at from $1.89 to $3.36 per acre. A similar procedure was applied to the other important commercial species, which are menhaden, oyster and blue crab. For blue crab, data from Florida's coastal wetlands were used, based upon a study by Lynne *et al.* (1981). For these species, the annual value of the marginal productivity varies from a low $0.67 per acre for blue crab to $8.04 per acre for oyster. Totalling the values gives a figure of about $25 for the annual marginal productivity of an acre of wetlands in supporting the various commercial fish species.

To generate a proper economic measure of the fishery benefits requires a more complex procedure that makes use of the annual value of marginal productivity, which we have estimated above, along with demand information, to calculate what economists refer to as *consumers'* and *producers' surpluses*. Ellis and Fisher (1987) illustrate the approach using data from the blue crab study referred to above, having demonstrated that the values estimated may be quite different from those based upon marginal productivity figures alone, so that the latter may be misleading if interpreted as a true measure of economic welfare. Freeman (1991) took their analysis a step further and showed that the true economic values will depend on whether the blue crab fishery is managed as a regulated or an unregulated resource.

Estimating the fur trapping benefits associated with the marsh similarly requires consideration of their marginal productivity for this purpose. However, only average productivity, as determined by the total harvest divided by the total area of the fur-bearers' wetland habitat, is available. This can result in either an overestimate or an underestimate of the true marginal yield, but must suffice in many valuation situations. The principal species trapped are muskrat and nutria, accounting together for about 78% of the local fur harvest. Average yields are 0.98 and 0.88 pelts per acre, respectively, and prices at the time of the study were in the range of $6 to $7 per pelt (1980-81 prices). Multiplying these figures gives the average productivity of an acre of wetland with respect to fur trapping, estimated as approximately $12.

Louisiana's coastal wetlands are also important for sport hunters, fishermen, photographers, boaters and other noncommercial recreational users. These benefits are assessed using two approaches aimed at measuring willingness-to-pay to visit the site: these are the contingent valuation approach (CVM), as described in detail in several earlier case studies, and the travel cost method (TCM). The latter approach, as outlined in Appendix 3, makes use of the expenditures incurred in visiting a site, together with an allowance for the opportunity cost of the travel time. From the relationship between travel cost, distance from the site and visitation rates, a site value can be inferred. The resulting economic values would represent consumers' surplus and therefore a proper measure of economic value.

The data required to apply both techniques were collected using a questionnaire left with site visitors, who returned their response by mail. Of 7,837 questionnaires distributed, 1,126 were returned, for a response rate of 14.4%. The travel cost information, together with wage data provided by the respondents, was used to calculate an aggregate annual willingness-to-pay to visit the site of $3.9 million. Expressed as an average value per acre, the willingness-to-pay is $6 per acre, but some researchers have cautioned against the use of per acre figures to present recreational values, arguing instead for a value per user (Bergstrom *et al.*, 1990). Alternative cases were considered where the wage applied to travel time (to reflect its opportunity cost) was reduced to either 60% or 30% of its value, resulting in lower willingness-to-pay figures.

Assessing the recreational values of the wetlands using the contingent valuation approach relied upon responses to a direct question, which followed a dichotomous choice format (i.e., a single value is presented and the respondents reply yes or no when queried whether they would be prepared to pay that amount to preserve the wetlands). The average willingness-to-pay to preserve the wetlands was estimated at $103.48 per household. In contrast, an alternative contingent valuation study of recreational values over a wider area of Louisiana's coastal wetlands found a willingness-to-pay of $360 per household. It is not certain how comparable the two sets of estimates are (Bergstrom *et al.*, 1990).

To extrapolate the value to an aggregate annual value, the researchers used fishing license data which provides information about the numbers of individuals using the area for fishing during the year (1982-83). Reconciling a willingness-to-pay measure expressed on a per household basis with numbers of individuals holding fishing licenses requires some assumptions. If it is assumed that there is only one licensee per household, then the aggregate annual willingness-to-pay is $5.7 million, whereas assuming each household member holds a license results in an aggregate annual value of $2.6 million. The value derived using the travel cost method falls between these two points.

The final wetland benefit considered is storm protection. The Gulf of Mexico coast of Louisiana is subjected to occasional hurricanes which can cause extensive damage to coastal and inland property from tidal surges and high winds. Making use of storm frequency information and records of hurricane damage, the researchers estimated a storm ‘damage function’ which relates expected damage to distance from the landfall of a hurricane. Loss of coastal wetlands reduces the protection afforded inland property and results in increases in damage which can be predicted by the model. For example, the recession of the coastal wetland zone under study by one mile would result in additional expected damage of $5.75 million annually. A more realistic loss of 207 feet along the coastal strip would result in additional expected damage of $128.30 per acre (of coastal strip) annually.

Table 4.5 presents the estimated values for the Terrebonne wetland area in present value form using 8% and 3% discount rates. Some explanation of these values is required. Since the population of the region has been growing rapidly, the researchers incorporated a 1.3% annual increase into their benefit estimates to take this into account. All figures are expressed on a per acre basis, although there may be some difficulties in interpreting some of the values in this way (i.e., recreation). It is evident from the assembled estimates that ecological functions, such as storm protection, may be very important components in the total economic value of a wetland area. Here these values constitute almost 80% of the estimated total.

The values contained in Table 4.5 represent only a few of the direct and indirect uses of Louisiana's coastal wetlands, and include no non-use values. Nonetheless, the case study illustrates the possibilities for valuation within a total valuation framework where data are reasonably good, while at the same time suggesting the limits that may be encountered. If only a few use values can be credibly quantified in such circumstances, it seems reasonable to conclude that few studies are likely to capture the full range of use and non-use values associated with a wetland. However, providing decision-makers with information of at least this magnitude may substantially improve the prospects for better resource allocation.

Table 4.5 Coastal wetland values in Louisiana, US ($US/ acre, 1983 prices)

Value	Present value per acre, 8% discount rate	Present value per acre, 3% discount rate
Commercial fishery	317	846
Trapping	151	401
Recreation	46	181
Storm protection	1915	7549
Total	2429	8977

Source: Costanza *et al.* (1989)

4.6 Valuation and mangrove conservation in Indonesia

The economic analysis of the mangrove wetlands of Bintuni Bay, Irian Jaya, Indonesia, illustrates the use of the total valuation approach, and in particular the importance that environmental linkages play in the economics of tropical wetland systems (Ruitenbeek 1992, 1994).

Mangroves in Indonesia are under threat from intensive use of their resources. Excessive exploitation of mangrove systems for charcoal, wood, fish ponds or similar resource uses is usually based on very narrow evaluation of only one of many possible 'productive' uses of these systems, often ignoring many important linkages among all the direct and indirect uses of the mangrove wetlands. In the 300,000 hectares of mangrove wetlands of Bintuni Bay, pressures from a woodchip export industry pose a direct threat to the mangrove ecosystem, also endangering its ability to support commercial shrimp fisheries, commercial sago production and traditional household production from hunting, fishing, gathering and manufacturing. The mangrove system also has important indirect use value through its environmental function of controlling erosion and sedimentation, which protects agricultural production in the region. In addition, the wetlands have been identified as an ecologically important and 'diverse' ecosystem, which would suggest a high biodiversity value if it were kept mainly 'intact'[18].

The total value of household income from marketed and non-marketed sources was estimated to be around Rp 9 million per year per household, of which about Rp 6.5 million can be attributed to traditional uses of the mangroves for hunting, fishing, gathering and manufacturing (Rp 2000 = US$ 1). Commercial shrimp production yields approximately Rp 70 billion per year, and if the by-catch fish production is ever commercially marketed, the imputed value of this catch is projected to exceed Rp 30

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18 Ruitenbeek (1992) correctly argues that this biodiversity value is only relevant to Indonesia if it is a "capturable biodiversity benefit", defined as "the potential benefit which the country might be able to obtain from the international community in exchange for maintaining its biodiversity base intact". In the analysis, an imputed value of US$ 1,500 per km^2 per year is thus ascribed as a capturable biodiversity benefit if the mangrove system is kept intact.

billion per year. Sago production could reach a sustainable level by the year 2000 and earn Rp 68 billion annually. In comparison, selective mangrove cutting schemes have a maximum value of about Rp 40 billion per year.

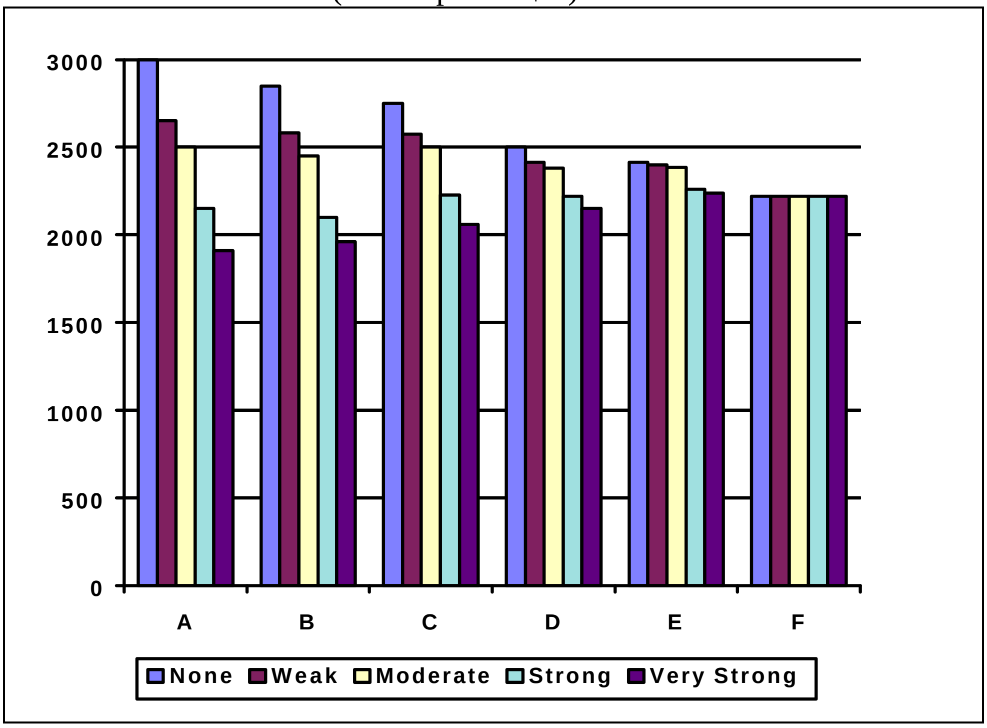
In the study, values were imputed to the benefits of erosion control and biodiversity. The imputed benefit of erosion control was based on its indirect use value in support of local agricultural production. This was estimated to be around Rp 1.9 million per household. Biodiversity values are expected to be 'capturable' through additional aid flows and other international transfers for conservation projects, which have an imputed value of Rp 30,000 per hectare.

The economic analysis compared different forest management options as to their effects on the total economic value of the mangrove wetlands. The forestry options ranged from complete clear cutting of the mangrove forest for woodchip production to selective cutting regimes of various intensities to a cutting ban. An important feature of the analysis was that it explicitly incorporated the linkages between mangrove conversion, offshore fishery productivity, traditional uses and the imputed benefits of erosion control and biodiversity maintenance. To the extent that these linkages exist, some of these direct and indirect uses become mutually exclusive with more intensive mangrove exploitation through forestry options. The 'optimal' forest management option will therefore depend on the strength of the environmental linkages.

The results are summarized in Figure 4.1. The 'very strong' linkage scenario suggests immediate linear linkage between changes in the forest area and other productive uses. 'Weaker' linkage scenarios involved nonlinear impacts with five- or ten-year delays. The analysis indicates that the clear cutting option is optimal only if no environmental linkages exist – a highly unrealistic assumption. At the other extreme, a cutting ban is only optimal if the linkages are very strong, i.e., mangrove alteration and conversion would lead to immediate and linear impacts throughout the ecosystem. Under a scenario of linear but delayed linkages of five years, selective cutting of the mangroves has a present value of Rp 70 billion greater than the clear cutting option, and only Rp 3 billion greater than the cutting ban option. Even if weak interactions exist, an 80% selective cutting policy with replanting is preferable to clear cutting. Given that there is still considerable uncertainty over the dynamics of the mangrove ecosystem, and that alteration and conversion may be irreversible and exhibit high economic costs, the analysis suggests that there is little economic advantage to cutting significant amounts (e.g., more than 25%) of the mangrove area in the Bintuni Bay wetlands.

Figure 4.1 Indonesia – total economic value of a mangrove system under varying environmental linkages

Economic value of mangrove system, Bintuni Bay, Indonesia
(Net present value in billions of 1991 Rp: 7.5% discount rate)
(2000 Rp = US$ 1)



Environmental Linkages - None to Very Strong

A	=	20 Year Clear Cut of Mangrove Forest
B	=	30 Year Clear Cut of Mangrove Forest
C	=	80% Selective Cut of Mangrove Forest
D	=	40% Selective Cut of Mangrove Forest
E	=	25% Selective Cut of Mangrove Forest
F	=	Ban on Cutting of Mangrove Forest

Source: Ruitenbeek (1992).

Total Net Benefits include: a) woodchip production from mangrove forest cutting, b) commercial shrimp and by-catch fish production, c) commercial sago production, d) traditional production from hunting, fishing, gathering and manufacturing, e) imputed benefit of erosion control, and f) capturable biodiversity.

In sum, the Bintuni Bay mangrove analysis demonstrates the importance of economic valuation of environmental linkages in wetland development decisions. The failure to take into account such linkages may lead to critical errors in these decisions, leading to a narrow focus on a single major productive use. The analysis also demonstrates the importance of valuing traditional uses of tropical wetlands, their environmental functions and their potential to generate future use and non-use values.

4.7 Conclusions from the case studies

The case studies presented include a wide range of policy problems and geographic settings, although their coverage cannot be claimed to be exhaustive in any way. Several observations emerge from reviewing these studies. First, the importance of integrating ecological, hydrological and economic approaches is critical, especially when the valuation of ecological functions is the objective. This requires more than complex mathematical techniques, but extends to continual collaboration between economists, hydrologists and ecologists. The studies also demonstrate that valuation should not be conceived as an end in itself, but needs to be directed towards some policy issue. These issues may range from simply raising awareness of the importance of wetlands to choices among alternatives to meet some stated policy goal, with protecting wetlands representing just one option.

A variety of valuation techniques is also shown in the case studies, and some clear patterns emerge. Most temperate wetlands studies recognize recreation as an important wetland use and most often use contingent valuation to obtain a measure for its value. In contrast, tropical studies are more concerned with the production values or direct uses associated with wetlands, and the predominant valuation technique is likely to be the measurement of the changes in the value of productivity. The indirect uses or ecological services provided by wetlands are important in both zones and a more complex valuation technique, as was used to value nitrogen abatement in Sweden, will often be required. Unfortunately, such techniques are data-hungry and expensive to implement, and for these reasons there are still relatively few instances where indirect use values have been successfully quantified.

Table 4.6 Summary Information for Wetland Valuation Case Studies

Case Study	Wetland Type	Location	Policy Issue	Approaches/ Techniques	Sample Values
Barbier et al. (1993)	tropical floodplain	Hadejia-Nguru wetlands, Nigeria	allocation of flood flows	partial valuation; loss of productivity, market prices	net present value of agriculture, forestry and fishing benefits; N109 (US$ 15)/10^3m^3; N381 (US$ 51)/ hectare (1989/90 prices, 8% discount rate over 50 years)
Hammack and Brown (1974)	freshwater ponds	Central North America	optimal conversion (drainage) for agriculture	partial valuation; CVM, production function, bioeconomic modelling	value of additional (marginal) waterfowl; US$ 2.40 - 4.65 per bird, depending on pond cost (1968-69 prices)
Bateman et al. (1993) **Hanley and Craig (1991)**	saline/freshwater wetland system upland peat bog	Norfolk Broads, U.K. Scottish Flow Country	protection from saline flooding; preservation or conversion to forest plantation	total valuation;CVM partial valuation; CVM	annual recreation and amenity use;£67 - 140 (US$ 118 - 247)/year/respondent (1991 prices); present value of preservation benefits; £16.79 (US$ 30)/respondent (1990 prices)
Gren (1995)	riverine wetlands	Gotland, Sweden	nitrogen abatement	partial valuation; CVM, production function, replacement cost	value of nitrogen abatement using wetlands; SEK 349 (US$ 59)/kg N reduction capacity (1990 prices)
Costanza et al. (1987)	semi-tropical coastal marsh	Louisiana, USA	gradual destruction	total valuation; market prices, damage/production function, CVM, TCM	net present value of commercial fishery, trapping, recreation and storm protection values; US$ 2,429/ac (1983 prices, 8% discount rate over infinite time horizon)
Ruitenbeek (1994)	mangroves	Bintuni Bay, Indonesia	conversion to woodchip production	total valuation; modified production function, sensitivity analysis	no information

5. Guidance Notes: the practicalities of planning and conducting a valuation study

When planning a valuation study, it is necessary to balance the benefits of using the best scientific techniques with the financial, data, time and skills limitations to be faced. This chapter provides practical advice on choosing the appropriate methodology and conducting a valuation study. The need for a multidisciplinary team is stressed, as well as the importance of the availability of ecological and hydrological data on the wetland and a quantitative understanding of its functioning. Guidance on qualitative valuation of rare species is also provided.

5.1 A step by step guide to undertaking a valuation study

The three stage appraisal framework presented in Chapter 3 can be further broken down into seven practical steps which must be followed to undertake an economic valuation of a wetland. These are presented in Box 5.1 and described below.

Step 1: choosing the appropriate assessment approach

There are three approaches: impact analysis; partial valuation; and total valuation. If the problem is a specific external impact, such as effluent polluting a wetland, *impact analysis* will be appropriate. If the problem is the necessity of making one choice between wetland use options, including conversion of the wetland to residential land or diversion of water upstream of the wetland to intensive irrigation, then a *partial valuation* would be the correct approach. Sometimes the problem is more general. For example, developing a national conservation strategy may require assessment of the total net benefits of the wetland system. In this case, a *total valuation* should be undertaken.

Step 2: defining the wetland area

The boundary of the wetland may already have been defined for political purposes, such as gazettement as a National Park or Ramsar site. No definitive methodology exists to delineate the boundary scientifically. This will be the first task for the multi-disciplinary team based on maps of flood extent, soils, agricultural use and vegetation.

Box 5.1 Seven steps to conducting a valuation study

Stage 1

1. Choose the appropriate assessment approach (impact analysis, partial valuation, total valuation);

Stage 2

2. define the wetland area and specify the system boundary between this area and the surrounding region;

3. identify the components, functions and attributes of the wetland ecosystem and rank them in terms of importance (e.g., high, medium, low);

4. relate the components, functions and attributes to the type of use value (e.g., direct use, indirect use and non-use);

5. identify the information required to assess each form of use (or non-use) which is to be valued and how to obtain the data;

Stage 3

6. use available information to quantify economic values, where possible;

7. implement the appropriate appraisal method, e.g., cost-benefit analysis (CBA).

Step 3: identifying and prioritising components, functions and attributes

The third step involves using various data sources, including scientific studies, consultancy reports and national resource inventories, to produce a more definitive list of components, functions and attributes present in the wetland, and then to place them in order of importance. This may be in rank order, say 1 to 10, or expressed as being of high, medium or low importance. A list of the major components, functions and attributes is given in Appendix 1. Clearly, no single wetland will exhibit all of these, and it is important for the multidisciplinary team to work together to identify the key components, functions and attributes of the wetland being studied and to use all available ecological, hydrological and economic information to score these various characteristics.

As discussed in Chapter 3, the distinction between components, functions and attributes is directly useful from an economic perspective, but scientists from other disciplines may have some difficulty with these concepts. Regardless of whether these characteristics or others are used, it is important that all members of the team understand their meaning and work together to establish priorities for valuation amongst themselves.

Step 4: relating components, functions and attributes to use value

The fourth step is to determine whether each of the components, functions and attributes is associated with a direct use, indirect use or non-use. Interviews with local communities, census data and consultancy reports are usually good sources of information on direct use. More detailed scientific investigation is usually required to uncover the indirect use values, concentrating on the physical links between wetland system functioning and the economic activities affected. Some of the more intangible values – option and existence values – may be more difficult to determine, and it will often be up to the multidisciplinary team to use its best judgement, keeping in mind the difficulties of quantifying these values.

Step 5: identifying and obtaining information required for assessment

The fifth step involves identifying and obtaining information required for the valuation. Different physical, chemical and biological data will be required depending on the values that are to be assessed, and the methodology for collecting and analysing the data must be specified. The range of data to be collected can be extremely diverse. For example, it may include fish population status, numbers of rare species, rates of groundwater recharge, amounts of flood storage, degree of nutrient retention or coastal protection and so forth.

Information on the extent and rate of various human uses of the wetland must also be collected. The types of data may again be diverse, including agricultural yields, fish catches, tourist use or reduction in annual damage from storms or floods. A variety of collection methods and sources may be required. Obtaining agricultural and fisheries yields, for example, may involve interviews with fishermen and farmers, collection of statistics from government offices and visits to markets. Travel agents or tour companies could provide data on tourism in general, whilst parks and protected areas will know visitor numbers. Insurance agencies may have information on flood and storm damage in the area, whilst environmental authorities may collect water quality data.

Information is required on all inputs and outputs for all economic activities that are either *directly* or *indirectly* supported or protected by wetland ecological functions. This will include the economic costs of the inputs (e.g., labour-time, materials, physical assets) and the prices of the outputs (products). On the inputs, a distinction needs to be made between purchased inputs (e.g., tools, licenses, hired labour) and non-cash inputs (e.g., use of their own or family labour and borrowed tools). Similarly, distinction must be made between outputs which are marketed (e.g., rice sold at the local market) and those which are non-marketed (e.g., fish eaten at home). Information is required on the producer prices, the final market prices and the transportation and other intermediary costs of marketed products. For non-marketed products, it is necessary to know their rates of consumption, and it may be helpful to obtain information on the market price of any substitute or alternative product.

The information required to assess non-use or preservation values is extremely difficult to collect for developing countries and may require specific studies to estimate willingness to pay. If such analysis is beyond the scope of the study, assessment of such values may warrant a qualitative rather than quantitative approach. This can be approached through interviews with local people and those outside the area who have a connection with it.

More general social and economic data should also be collected on communities living within the wetlands or where they benefit from, or are affected by, wetland functions. For example, this may include population growth rates, income levels, credit facilities and rates of interest, inflation and exchange rates.

Data collection should begin with a *literature survey* of available statistics, existing studies, and their analysis for the region, which may yield some of the required information. Next, any *site surveys* of specific economic activities should be undertaken. In the first instance, a *rapid rural appraisal* based on brief farmer or producer interviews and group participation may be relevant to collecting basic information on human uses and economic data. More detailed *baseline surveys* may be required for in-depth data collection for actual valuation purposes. In all cases, it is important to be clear in advance about the information required so as to avoid collecting 'data for data's sake'.

Step 6: quantifying economic values

In this step the appropriate valuation techniques should be selected and implemented. These are discussed fully in Chapters 3 and 4. As noted in those chapters, there are many sophisticated techniques, such as contingent valuation and hedonic pricing, which are being applied to value temperate wetland functions, products and attributes, and such methods are increasingly being implemented in tropical regions as well. However, these techniques may not always be appropriate in developing countries. Although alternative approaches are available, some of these may yield extremely inaccurate valuation estimates. Care must therefore be exercised in choosing a technique which is theoretically sound but which is also appropriate to the circumstances where it will be applied.

Step 7: implementing the appropriate appraisal method

In the final step, the economic analysis of the wetlands should be placed in the appropriate framework as selected during the planning for the study. An example is *cost-benefit analysis* (CBA), which normally involves calculating on an annual basis the benefits and costs of conserving the natural wetland functions, products and attributes over a selected time period (see Box 3.2). The three most common methods for comparing costs and benefits are *net present value*, *internal rate of return* and *benefit-cost ratio*. Any valuation should be subject to a sensitivity analysis, which defines the variation in results arising from different assumptions or benchmark values used in the study, such as discount rates.

However, CBA is not the only possible appraisal method available, and other frameworks, such as environmental impact assessment, multi-criteria analysis and risk assessment may also require economic valuation as part of the assessment procedure. Initial planning of the study should determine which framework for assessing costs and benefits is desirable, as the choice of framework may affect all seven steps of the analysis.

5.2 Resources required for a valuation study

The cost of undertaking a valuation study will vary enormously from country to country and from wetland to wetland. Consequently it is not possible to quantify the investment required. It is possible, however, to highlight the factors which determine the costs.

Data availability will determine to a large extent the appropriate level of effort. Clearly, if sufficient economic and environmental data are readily available, a valuation study may be rapid and inexpensive, requiring only, say, a few person-months of effort. Step 5 (in Box 5.1) will involve collating data held by various authorities or published in journals. In other cases primary data collection may be necessary, which can involve (if time and the budget are sufficient) many person-years of effort, plus, in the case of hydrological and biological data, expensive field equipment.

A good valuation study is based on good quality data. Bacon (1992), for example, when approaching the valuation of Caribbean coastal wetlands, stressed that data should not be restricted to lists of species. Forest structure and mensuration, plant growth rates and stock densities, animal population sizes and dynamics, including seasonality, are all essential. In addition, detailed knowledge of the hydrological functioning of the wetland is required, including tidal cycles, sedimentation, groundwater recharge and pollutant retention. To quantify these accurately, long-term hydrological records are needed, particularly in regions with highly variable climatic regimes. Such records are very rare and costly to collect.

Some economic data, such as the price of fuelwood or livestock over many years, may be available from local government offices, and collection and analysis may take a few tens of man-days. In contrast, the recreational value of a wetland may not be known and several contingent valuation surveys may be required, involving several hundred man-days of work, including training of survey staff, interviews and analysis (see Boxes 5.2 and 5.3). As with the environmental data, long time series may be required, if, for example, the value of the wetland resources varies widely from year to year (in wet years or times of drought).

Box 5.2 Costs of undertaking a contingent valuation study in UK

Contingent valuation (see Box 3.8) is normally undertaken by face-to-face interviews (mail-based surveys cost considerably less, but the response rate is often lower). The following example gives details of a contingent valuation study undertaken in UK involving three steps: focus groups (to pilot questionnaire), the pilot questionnaire and then full questionnaire[1]. It involves training 12 interviewers, 8 of whom are sent out at any one time (4 to one town and 4 to another), travelling about 40 km by car from the research centre. The survey is based on a pilot of 160 people and a main survey of 1200, 600 at each site. Each interviewer is paid US$ 8[2] per hour, and it is assumed that 10 questionnaires are completed in a session (the interview is quite long and detailed).

	US$
two preliminary focus groups (piloting questionnaire)	690
interviewer training/practice	750
interviewer wages (piloting)	1000
interviewer travel (piloting)	100
interviewer wages (survey)	7500
interviewer travel (survey)	770
debriefing half-day	380
printing/photocopying, show cards and information sheets	2780
Total	13970

There then follows a data analysis and report writing phase, the cost of which depends on the scale and complexity of the study and on whether it is a public or private sector-based study. For a university-based study this would include the researcher's salary ($30,000 per year plus consumables). For a six month study the total costs would be:

	US$
researcher's salary (6 months)	15600[3]
consumables	1550
survey	13970
Grand Total	31120

Notes:

1. For more complex problems focus groups may be set up to define the context, scope and information requirements, psychological/cultural factors: it is assumed here that 6-8 people attend each focus group and are paid US$30 for attending a 90 minute session plus travelling expenses, room hire, etc.
2. An exchange rate of US$1 = £ 0.64
3. This does not include any overheads of the University.

Source: Centre for Social and Economic Research on the Global Environment, University of East Anglia, UK.

Box 5.3 Costs of undertaking a valuation study in Nigeria

This example relates to a study of the value of the groundwater, much of which is recharged from a nearby wetland. Face-to-face interviews were held to determine the value of water extracted from village wells. Separate studies were undertaken to determine the hydrological processes in the wetlands and the rates of groundwater recharge, the costs of which are not included here. The costs below are for survey work, training, travel within the study area, and printing survey sheets.

The survey involved 4 months of field work and was conducted over two seasons and in two parts of the wetland. A total of 150 households were interviewed.

	US$
10 interviewers (5 weeks for first survey)	900[1]
6 interviewers (5 weeks for second survey)	550

This includes 1 week training and 1 week practising questionnaires.

3 well dippers (for 6 months)	164

to collect records of groundwater levels

travel costs (10 weeks)	284
printing/photocopying	340
Total	2238

Expenses for expatriate expert:	US$
salary (6 months)	15600[2]
air fare	1875
living expenses	470
report production	782
Grand total	20965

Notes:
1. At an exchange rate of US$1 = 88 Naira
2. This does not include any institutional overheads.

Source: Department of Environmental Economics and Environmental Management, University of York, UK.

Time may be short if results are needed before a fixed date when a decision will be made. In this case there may not be time to install hydrometric equipment or undertake ecological or socio-economic surveys. In many cases, a fixed budget will be available, and this will determine the number of staff that can be employed and the data collection methods. If few data exist and time or money preclude their collection, an application of benefits transfer may be all that can be achieved (see Box 3.7).

A further issue is that the required skills may not be readily available in or near the wetland to be studied. In this case experts from other areas or other countries may need to be brought in to advise on, or undertake, the study. Rates of pay may be higher and accommodation will need to be provided and transport costs considered.

5.3 The valuation study team and sample Terms of Reference

Normally the policy maker or his or her staff will plan the study but specialists will be needed for technical aspects of the work. The focal point of the study will clearly be the economist, whose task will be to quantify the direct, indirect and non-use values of the wetland goods and services and to incorporate this analysis in the calculation of costs and benefits of actions. However, it is evident that economic valuation is a multidisciplinary exercise. For example, Step 3 (in Box 5.1) shows that a major task is to identify the components, functions and attributes of the wetland ecosystem and rank them in terms of importance (e.g., high, medium, low). This normally requires the input of an ecologist, or natural resource specialist, and a hydrologist, or water resources specialist. Thus, an interdisciplinary approach is needed.

An essential step in the management of a valuation study is the production of Terms of Reference for experts. Since each study will be very different, it is not possible to produce generic Terms of Reference, although the list of steps given in Box 5.1 provides a framework. Consequently, we use the following fictitious example to serve as an illustration.

The hypothetical River Zed in Africa has a large floodplain along its middle course. It has many components, including fisheries and forests, which perform functions such as groundwater recharge and possess attributes such as biodiversity. A dam has been built in the headwaters to supply water to an intensive irrigation scheme. Since the construction of the dam, the area of the floodplain that becomes inundated has been reduced, fish stocks and wildlife have declined, floodplain trees have started to die and water levels in the wells within and beyond the wetlands have fallen. The dam contains sluice gates which can allow water to be released during the wet season to augment the natural flood.

The River Basin Development Authority has decided to commission an economic valuation of the wetlands to assess whether the economy of the region would be best served by using the water from the river for intensive irrigation or by conserving the components, functions and attributes of the wetlands. A scoping study has shown that fisheries and groundwater recharge are the most important characteristics of the floodplain. A multidisciplinary team has been assembled led by three consultants: a hydrologist, a fish ecologist and an environmental economist. A survey team is established to interview users.

The Terms of Reference for the three consultants are given in Box 5.4, 5.5 and 5.6.

Box 5.4 Terms of Reference for the hydrologist

1. Determine the relationship between inflows to the floodplain and the area inundated;

2. Determine the rate of groundwater recharge and its relationship with the area of the floodplain inundated.

3. Organise, support and supervise the collection of data by a field team on water use from wells and boreholes.

4. Determine the water use of the intensive irrigation scheme.

5. Analyse the data and produce summary statistics suitable for economic analysis.

Box 5.5 Terms of Reference for the fish ecologist

1. Determine the relationship between fish populations and area of the floodplain inundated;

2. Organise, support and supervise the collection of data by a field team on fish catches from the floodplain.

3. Analyse the data and produce summary statistics suitable for economic analysis.

Box 5.6 Terms of Reference for the economist

1. Organise, support and supervise the collection by a survey team of economic data related to fisheries within the floodplain and water use from wells in the surrounding areas which are recharged from the floodplain.

2. Analyse the survey data to determine the economic value of fisheries and groundwater recharge within the wetland (giving the results as US$ per unit volume of water)

3. Assess the economic performance of the intensive irrigation scheme (in terms of US$ per unit volume of water).

4. Compare the results of the value of water use in the floodplain with that in the intensive irrigation scheme.

5.4 Non-economic factors

It is also important to consider the other political, social, historical or ecological issues which may be weighed alongside the economic valuation results when a decision is being made. Political considerations may include the obligations of a state under international conventions such as the Biodiversity and Ramsar Conventions. Consequently, species may therefore be protected without the need to show that this might have an economic benefit. Some states have agreements to ensure that certain quantities of water flow downstream to their neighbours along international rivers. Decisions on wetland management may also be affected by national policies, such as the desire to make a country self-sufficient in rice, which could be used as an argument for intensive irrigation of former wetlands, even where the traditional extensive farming methods may make more efficient use of water. Social considerations may include the decision to maintain traditional ways of life which depend on wetland resources, such as fishing, flood recession agriculture and herding, and which govern the social fabric of a local society, thus effectively giving them a high value. Preservation of archaeological wetland sites, for historical reasons, may be important. Other issues which may need to be considered along with the conventional economic cost-benefit analysis are moral attitudes – for example, wetlands may be retained to conserve an endangered species. Information on the above issues will need to be collected to demonstrate the economic implications of such policies and decisions. The issue of endangered species is developed further in section 5.5 below.

5.5 Conservation of rare species

There are strong arguments from many ecologists that willingness to pay (or to accept payment) should not be the only criterion used to make decisions about wetland use, particularly where conversion or exploitation may lead to the degradation of essential (life-support) functions, such as atmospheric circulation or the loss, or decline, of rare species. It may be argued that insufficient information is available on the true value of a species due to lack of scientific knowledge. Also some believe that we should have moral obligations towards other species beyond any economic value.

The World Conservation Strategy (IUCN, 1980) advises against the extinction of species and promotes species diversity to maintain biological stability (and by implication the stability of economic production dependent on biological resources) and to keep options open for the future. The future value of species and genetic diversity is imperfectly known and important uses may be found, the value of which is also currently unknown. In this situation, to replace or supplement the standard cost-benefit analysis approach, alternative assessment methods are required which are consistent with the precautionary principle, such as the safe minimum standard of conservation (see Box 3.1). Since, in reality, some species extinction will continue, efforts should be focused on those which are most vulnerable, by setting priorities according to rarity and whether a single species, whole genus or whole family is at stake. Priorities from 1-9 are given in Table 5.1.

As Tisdell (1990) describes, no specific account is taken of the costs and benefits of preservation of the species, but the net benefit is assumed to be greater the more unique the species is in relation to the biological classification system and the more imminent the loss. Whilst the World Conservation Strategy recognises the importance of the interdependence of species and points out that the removal of any species which form part of a food chain may result in the loss of dependent species, allowance for this function of the species is not incorporated into the schema. Randall (1986) argues that since all species are interconnected the sequence of disappearance is vital.

Table 5.1 Formulation for determining priority of threatened species (after IUCN, 1990)

	rare	**vulnerable**	**endangered**
species	9	8	6
genus	7	5	3
family	4	2	1

6. Recommendations

6.1 Economic valuation studies

Decisions affecting wetlands are frequently made on economic and financial grounds. If wetland conservation is to compete on these terms with alternative land uses, a quantitative value for wetland components, functions and attributes needs to be calculated. This can be achieved by defining the direct and indirect uses and non-use of wetlands and people's willingness to pay for these services. Economic valuation can be useful at a number of levels including impact of specific developments, making choices between options and setting regional or national policy.

Recommendation 1 – Economic valuation studies of wetlands should be undertaken to make sound decisions on development options and to set regional and national policy.

6.2 Interdisciplinary collaboration

Although pure valuation itself is part of economics, and therefore a subject for economists, valuation of wetlands also requires an understanding of the functions of the wetland and therefore requires an interdisciplinary approach. For example, there is currently a study in northern Nigeria to value the groundwater recharge function of Hadejia-Nguru wetlands. The users of the groundwater are people who live downstream and beyond the wetlands. The study involves analysing the use of the water, whether for washing, cooking, crop irrigation or livestock watering. But not all the groundwater comes from recharge in the wetlands – some derives directly from rainfall or through the bed of the river. Calculating the contribution that the wetlands play in recharging the aquifer is a subject for the hydrologist. Data collection involves measuring the quantity of water drawn from village wells and then dividing this amongst the various uses. If this division is not known explicitly, it can be inferred from knowledge of the water requirements of livestock and of the crops irrigated in the village. This requires the skills of an agronomist.

This example demonstrates the interdisciplinary nature of wetland valuation studies and the need for multidisciplinary teams.

Recommendation 2 – Economists, ecologists, hydrologists, agronomists, engineers and other experts should work together as a multidisciplinary team to tackle wetland valuation.

6.3 Training and institutional capacity building

To ensure that economic valuation is correctly applied and that the results are used effectively in decision-making, training and institutional capacity building are essential. Planners and decision-makers should be exposed at a general level to wetland valuation techniques but, more specifically, they should be trained in planning and managing valuation studies and in how to make the best use of the results to underpin sound policy development and decision-making. Economists with 'traditional' backgrounds may need detailed training on environmental valuation methods used in wetland valuation techniques and on how to manage teams of support staff to collect the required information. Economists will also require training on wetland functioning.

Recommendation 3 – Economists, planners and decision-makers should be trained in wetland valuation techniques as part of broad-based environmental management courses.

6.4 Research

There is an urgent need for more research to improve wetland valuation techniques. This is especially the case for non-use values and for application in developing countries where markets are distorted or countries cannot appropriate the true value. Contingent valuation has been criticised as a technique, but many of the problems are due to difficulties in applying the technique rather than the concept itself. Funds should be found to undertake a wide range of case studies throughout the world in different wetlands, different economic situations and using different techniques to ascertain which methods are applicable under which circumstances and where fundamental research effort is most badly needed.

Recommendation 4 – A wide range of case studies should be undertaken throughout the world in different wetlands, different economic situations and using different techniques to ascertain which methods are applicable under which circumstances and to focus fundamental research where it is most needed.

6.5 Networking

Results of research and experience from application of valuation techniques are rarely disseminated adequately. Networks of experts can be a useful medium for exchange of ideas and information. Two types are required: first, a network by which researchers can exchange results and discuss basic principles; and second, a network by which practitioners can swap experiences of applying methods in different wetland types, focusing on the practicalities of finding information, undertaking surveys and assessing the response to questionnaires.

Recommendation 5 – Two networks should be established. First, a network of researchers to exchange results and to discuss basic principles. Second, a network of practitioners to exchange experience of applying methods in different wetland types, focusing on the practicalities of finding information, undertaking surveys and assessing the response to questionnaires.

7. Glossary

Benefits transfer – the practice of using values estimated for an alternative wetland site as a basis for estimating a value for the site in question (see Box 3.7).

Contingent valuation – a valuation from a survey technique using direct questioning of individuals to estimate individuals' willingness to pay (see Box 3.8).

Cost-benefit analysis – the appraisal of all the social and economic costs and benefits accruing from a decision or project.

Demand – the desire for a good or service supported by the means to purchase it.

Developing country – a country that has not yet reached the stage of economic development characterised by the growth of industrialisation, nor a level of national income sufficient to yield the domestic savings required to finance the investment necessary for further growth.

Direct use value – the value derived from direct use or interaction with a wetland's resources and services, such as the value of fish catches.

Discount rate – the calculation of present value by application of a discount rate to a capital sum (see Box 3.2).

Economic efficiency – Economic efficiency is the allocation of resources in the economy that yields an overall net gain to society as measured through valuation in terms of the benefits of each use minus its costs.

Impact analysis – an assessment of the damages inflicted on a wetland from a specific external environmental impact (e.g., oil spills on a coastal wetland).

Indirect opportunity cost – the time spent on an activity, such as harvesting, valued in terms of foregone rural wages.

Indirect use value – indirect support and protection provided to economic activity and property by the tropical wetlands' natural functions, or regulatory 'environmental' services, such as flood alleviation.

Interest – the charge made for the use of borrowed money normally levied as a percentage.

Intrinsic value – the worth of something in itself regardless of whether it serves as an instrument for satisfying individuals' needs and preferences.

Market – A collection of transactions whereby potential sellers of a good or service are brought into contact with potential buyers and the means of exchange is available.

Net present value – the discounted value of a financial sum at some point in the future due to financial flows over a number of years from, for example, interest.

Non-use value – the value derived neither from current direct nor from indirect use of the wetlands, such as cultural heritage.

Opportunity cost – the value of that which must be given up to acquire or achieve something.

Partial valuation – assessment of two or more *alternative wetland use options* (e.g., whether to divert water from the wetlands for other uses, or to convert or develop part of the wetlands at the expense of other uses).

Public good – where one individual may benefit from the existence of some environmental good or service without reducing the benefit another individual can receive from the same good or service.

Shadow price – price 'adjusted' to eliminate any distortions caused by policies or market imperfections so as to reflect true willingness to pay.

Social cost – the total cost to society of an economic activity.

Surrogate market price – the use of an actual market price of a related good or service to value the wetland use that is non-marketed.

Total valuation – assessment of the *total economic contributions*, or net benefits, to society of the wetland system (e.g., for national income accounting or to determine its worth as a protected area).

Travel cost – the value of visiting wetland areas derived from the cost of travel, including recognition of the opportunity costs of travel time.

Supply – the quantity of good or service available for purchase.

Valuation – quantification of the values of a good or service.

Value – the worth of good or service, generally measured in terms of what we are willing to pay for it, less what it costs to supply it.

Wetland function – processes among and within the various biological, chemical and physical components of a wetland, such as nutrient cycling, biological productivity and groundwater recharge.

Willingness to pay – the amount that someone is prepared to pay to purchase a good or use of a service regardless of whether there is a prevailing market price or the good or service is available free of charge.

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Appendix 1

Wetland components, functions and attributes and their human uses

1.1 Introduction

The complex interactions between water, soils, topography, micro-organisms, plants and animals make wetlands amongst the Earth's most productive ecosystems. People may exploit these *components* directly as *products* (fish, timber, wildlife) or they may benefit *indirectly* from the interactions between the components expressed as *functions* (groundwater recharge, storm protection). People may also just appreciate wetlands for their mere *existence* (if they are part of their cultural heritage) without directly using them. It is use of these various characteristics that gives the wetlands high economic values and supports millions of people directly, whilst providing goods and services to the world outside the wetland. Wetland valuation means the quantification of the economic value of use of the wetland components, functions and attributes. Consequently, these concepts must be understood if the true value of wetlands is to be derived. In this appendix further details of wetland characteristics are given, together with their use.

1.2 Components

Wetland components provide many goods of great value, including:

1.2.1 Fish

Two thirds of the fish we eat depend upon wetlands at some stage of their life cycle. Many species of edible fish breed exclusively on inundated floodplains, and it has been estimated that over 100,000 tons per year are caught from the inner delta of the Niger alone.

The Banc d'Arguin National Park in Mauritania is the largest area of tidal flats in Africa and plays a critically important role in maintenance of offshore fisheries, which in 1980 contributed 77,100 metric tons of fish and US$ 34.3 million to the national economy.

1.2.2 Timber, fuelwood and tree products

Wetlands provide vital supplies of timber for construction, fuelwood for cooking and heating, and other tree products such as medicines.

Along the Pacific coast of Nicaragua, mangroves yield timber for construction, fuelwood, charcoal and bark, used to extract tannins. The *Melaleuca* wetland forests of Vietnam and Thailand provide a wide range of products, including locally-used medicines. In Matang Forest Reserve, Malaysia, 40,000 hectares of mangroves annually yield timber worth US$ 9 million (Ong, 1982).

1.2.3 Wildlife

The Okavango delta is one of the world's most outstanding wildlife areas with diverse plant communities and numerous species of macro- and micro-invertebrates, herbivores and birds which owe their existence to annual flooding. The delta is home to over 15 species of antelope, including the shy sitatunga and large herds of lechwe (Dugan, 1993). Likewise the nearby floodplains of the Zambezi river basin, including, for example, the Kafue and Luena Flats, support an outstanding diversity of wetland organisms, including over 4,500 species of higher plants, particularly ferns, grasses and orchids, and more than 400 species of birds. The aquatic environment is equally diverse with 120 species of fish (Howard, 1993). Floodplains in Sahelian Africa are equally important for wildlife. Annual inundation of the Hadejia-Nguru wetlands has made them an internationally important site for birds, with over 265 species either resident or visiting the area.

Wildlife is exploited in a number of ways. Tourism is particularly important in many wetlands. Nearly a million people visit the

Florida Everglades National Park each year, and many thousands travel to the southern African wetlands of the Okavango and Lake Kariba. Visitors to Morrocoy National Park in Venezuela are estimated to spend over U$ 7 million per annum (Delgado, 1986), and annual cash income from tourists at Caroni Swamp in Trinidad is US$ 2 million. Here revenue may be from access permits or for guides or boat drivers. Scientific studies, film and documentary making are other forms of non-consumptive direct use. Hunting of ducks or deer is clearly a consumptive use, which may bring revenue in the form of licenses as well as the value of the meat.

1.2.4 Fertile land for agriculture

Periodic inundation of floodplains and other wetlands promotes deposition of fertile soils and maintains the fertility of riparian land.

Throughout west Africa, particularly on the major floodplains such as the Inner Niger Delta in Mali, rice cultivation has been developed to benefit from annual flooding. In the Kelqin Region of Inner Mongolia, animal husbandry comprises 49% of the local economy, and the margins of large wetlands provide moist land in an otherwise semi-arid environment where farmers harvest natural fodder for their horses, cattle, sheep and goats.

In addition, wetlands provide a range of other products, including reeds for thatching and mat-making, medicines and fruits which are key to the income base of local villages.

1.2.5 Water supply

Wetlands are an obvious source of water for domestic, agricultural (irrigation, livestock) or industrial use. Surface or near-surface water is a characteristic of many wetland types, such as lakes, rivers, mires and bogs, and is thus easily available for direct use.

1.2.6 Water transport

Many communities have developed close to or actually on wetlands and use the waterways as a means of transport. On Lake Titicaca, communities live on floating islands of reed mats and communication among communities is entirely by boat. Along the Pacific coast of Nicaragua, channels within the mangroves provide the only means of communication between settlements. Canals are an example of the creation of artificial wetlands specifically for transport.

1.2.7 Peat

Many wetlands in both temperate and tropical climates are underlain by peat soils. Peat can provide an important fuel source and may be extracted on a local subsistence scale. Peat has also been in great demand in developed countries as garden compost and is extracted commercially by multinational corporations.

1.3 Functions

1.3.1 Flood control

The control exercised on floods depends on the type of wetland. Saturated river margins allow little storage, hence rainfall or up-slope runoff is transferred directly to the river. These are called contributing areas and may augment river flow.

In contrast, floodplains store large quantities of water during floods. This reduces the height of the flood peak and thus reduces flood risk downstream.

In the Charles River, Massachusetts, conservation of 3,800 hectares of wetlands along the main stream provides natural valley storage of flood water. It is estimated that if these wetlands had been destroyed by reclamation, the increased flood damage would have cost US$ 17 million each year (US Army Corps of Engineers).

1.3.2 Storm Protection

Coastal storms cause severe flooding in many parts of the world, from the Netherlands to Bangladesh. Coastal wetlands, particularly mangroves, help to dissipate the force and lessen the damage of wind and wave action.
The Indus delta and its mangrove forests help protect the coast and Pakistan's second most important port, Port Qasim, against the southwest monsoon (Meynell & Qureshi, 1995), thus avoiding the need for expensive dredging. In November 1993, when a cyclone hit the coast, at Keti Bunder, an area devoid of mangroves, considerable damage occurred, whereas Shah Bunder was not affected due to protection afforded by its mangrove forest.

1.3.3 Groundwater recharge

Many wetlands exist because their soils are impervious, thus precluding significant groundwater recharging. However, periodically inundated floodplains often have more permeable soils and groundwater recharge is recognized as an important function.

Hollis *et al.* (1993) concluded that recharge in the Hadejia and Jama'are river basins of northern Nigeria occurs primarily during flood flows, since the floodplain provides a large surface area and the river bed is often impermeable.

1.3.4 Sediment/pollutant retention

Sediment is often the major pollutant in many rivers' basins. Because wetlands commonly occupy basins, they may serve as sediment settling ponds. Where reeds and grasses are present, river velocities are slowed and the opportunity for settling is increased. Because pollutants (such as heavy metals) often adhere to suspended sediment, they may be retained simultaneously with the sediment.

Khan (1995) described the important functions of the 75,000 hectare North Selangor Peat Swamp forest, which borders one of the largest rice schemes in Malaysia. These wetlands mitigate floods and maintain high water quality. In recent years the forests have been cleared for agriculture and tin mining, reducing the buffering effect on pollution and releasing sediment. It is forecast that further clearance would result in significant water quality problems in the rice scheme.

1.3.5 Nutrient retention

This function occurs when nutrients, most importantly nitrogen and phosphorus, accumulate in the sub-soil or are stored in vegetation. Nitrates can be converted back to gaseous nitrogen and circulated back to the atmosphere as a result of denitrification.

In Uganda, the National Sewerage and Water Corporation is supporting conservation of papyrus swamps and other wetlands near Kampala because of the role they play in absorbing sewage and in purifying water supplies. Thus they serve as a low cost alternative to industrial sewage treatment.

1.3.6 Evaporation

Evaporation is normally dismissed as being a simple loss from a wetland. Hare (1985) suggested, however, that much inland rainfall actually derives from locally evaporated water and not from moist air from the oceans. This idea has been explored in the Sahel by Savenije (1995), who postulated that evaporation from wetlands creates rainfall nearby. However, in some wetlands water is recycled internally, which stabilises climatic conditions. In the valleys of southwest Uganda, concern for the effect of wetland loss on the local micro-climate was an important factor in the 1986 ban on wetland drainage.

1.3.7 Preservation

Acidic waterlogged bogs in particular have preserved important archaeological and human remains. For example, track ways built by prehistoric man have been found in the Somerset Levels in England and remarkably preserved corpses in Denmark.

However, it is important to note that not all wetlands perform all of these hydrological functions to the same extent, if at all. Indeed, some wetlands perform hydrological functions which may be contrary to human needs, such as riparian wetlands which may act as runoff generating areas, thus increasing flood risk downstream.

1.4 Attributes

1.4.1 Biological diversity

There is still some uncertainty as to the benefits of biodiversity to man, although it is widely accepted that the higher the diversity the more stable the ecosystem. In addition, many people take pleasure simply in the existence of biological diversity and place a high value on it.

1.4.2 Cultural heritage

The Marsh Arabs of southern Iraq have lived for centuries on artificial islands in the marshes at the confluence of the Tigris and Euphrates rivers. Their lives are very much in harmony with the wetlands, and they have a spiritual connection which is somehow different from the direct use of the wetland products they employ to build boats and houses and defend themselves from enemies. The Fens of East Anglia and Somerset Levels in the UK are also important for their cultural heritage. Here fewer people depend directly on the wetlands for their livelihood, but they are no less a fundamental part of life for local people. Also people who have moved away from the area and live in a town hold pleasant memories of life in the wetland.

Appendix 2:

Comparison of economic appraisal methods

Appraisal framework	Description/purpose	Advantages	Disadvantages
Land suitability/ classification.	Distinguish and map areas in terms of characteristics which determine suitability for different uses.	Distills a mass of physical, biological and (sometimes) economic information into a single index of relative suitability for various land uses.	Economic comparisons are rarely made explicit and the relative importance of different factors in calculating the final index may be arbitrary.
Environmental appraisal or environmental impact assessment.	Detailed documentation of environmental impacts, adverse effects and mitigation alternatives.	Explicitly requires consideration of environmental effects; ability to monetise does not preempt enumeration of all benefits and costs of an action.	Difficult to integrate descriptive analyses of intangible effects with monetary benefits and costs; not designed to assess trade-offs among options.

Economic valuation of wetlands

Cost-benefit analysis (CBA)	Evaluate projects, land use options and policies based on monetization of net benefits (benefits minus costs)	Considers the value (in terms of willingness to pay) and costs of actions; translates outcomes into commensurate terms; consistent with judging by efficiency implications.	No direct consideration of distribution of benefits and costs; significant informational requirements; tends to omit outputs whose effects cannot be quantified; tends to lead to maintenance of status quo; contingent on existing distribution of income and wealth.
Cost-effectiveness analysis (CEA)	Selects land use option that will minimise costs of realising a defined non-monetary objective.	No need to value benefits; focus on cost information more readily available; provides implicit values of objectives (e.g.,marginal cost of increasing by one unit).	No consideration given to relative importance of outputs; degree to which all costs are considered will be important to judgements as to “best” approach.

Multi criteria analysis (MCA)	Uses mathematical programming techniques to select options based on objective functions including weighted goals of decision-makers with explicit considerations of constraints and costs.	Offers consistent basis for making decisions; fully reflects all goals and constraints incorporated in model; allows for quantification of the implicit cost of constraints; permits prioritizing of projects.	Results only as good as inputs to mode; unrealistic characterisation of decision process; must supply the weight to be assigned to goals; large information needs for quantification.
Risk-benefit analysis (RBA)	Evaluate benefits associated with a land use option in comparison with risks.	Framework is left vague for flexibility; intended to permit consideration of all risks, benefits and costs; not an automatic decision rule.	Too vague; factors considered to be commensurate often are not.
Decision analysis (DA)	Step-by-step analysis of the consequences of choices under uncertainty.	Allows various objectives to be used; makes choices explicit; explicit recognition of uncertainty.	Objectives not always clear; no clear mechanism for assigning weights.

Macro-economic and behaviour models.	Econometric programming models used to simulate intersectoral linkages and producer behaviour.	Dynamic and price-endogenous models allow explicit simulation of feedback effects and price movements; best for large scale projects and land use allocation.	Tend to be data and analysis intensive; expensive to build and run and often difficult to interpret.

Source: IIED (1980) adapted from Pearce and Markandya (1989)

Appendix 3

Advantages and disadvantages of valuation techniques used in the economic appraisal of wetlands

Valuation technique	Advantages	Disadvantages
Market prices method Use prevailing prices for goods and services traded in domestic or international markets.	Market prices reflect the private willingness to pay for wetland costs and benefits that are traded (e.g., fish, timber, fuelwood, recreation). They may be used to construct financial accounts to compare alternative wetland uses from the perspective of the individual or company concerned with private profit and losses. Price data are relatively easy to obtain.	Market imperfections and/or policy failures may distort market prices which will therefore fail to reflect the economic value of goods or services to society as a whole. Seasonal variations and other effects on prices need to be considered when market prices are used in economic analysis.

Efficiency (shadow) prices method Use of market prices but adjusted for transfer payments, market imperfections and policy distortions. May also incorporate distribution weights, where equality concerns are made explicit. Shadow prices may also be calculated for non-marketed goods.	Efficiency prices reflect the true economic value or opportunity cost, to society as a whole, of goods and services that are traded in domestic or international markets (e.g., fish, fuelwood, peat)	Derivation of efficiency prices is complex and may require substantial data. Apparently 'artificial' prices may not be accepted by decision-makers.
Hedonic pricing method The value of an environmental amenity (such as a view) is obtained from property or labour markets. The basic assumption is that the observed property value (or wage) reflects a stream of benefits (or working conditions) and that it is possible to isolate the value of the relevant environmental amenity or attribute.	Hedonic pricing has potential for valuing certain wetland functions (e.g., storm protection, groundwater recharge) in terms of their impact on land values, assuming that the wetland functions are fully reflected in land prices.	Application of hedonic pricing to the environmental functions of wetlands requires that these values are reflected in surrogate markets. The approach may be limited where markets are distorted, choices are constrained by income, information about environmental conditions is not widespread and data are scarce.

Travel cost approach The travel cost approach derives willingness to pay for environmental benefits at a specific location by using information on the amount of money and time that people spend to visit the location.	Widely used to estimate the value of recreational sites including public parks and wildlife reserves in developed countries. It could be used to estimate willingness to pay for eco-tourism to tropical wetlands in some developing countries.	Data intensive; restrictive assumptions about consumer behaviour (e.g., multi-functional trips); results highly sensitive to statistical methods used to specify the demand relationship.
Production function approach Estimates the value of a non-marketed resource or ecological function in terms of changes in economic activity by modelling the physical contribution of the resource or function to economic output.	Widely used to estimate the impact of wetlands and reef destruction, deforestation and water pollution, etc., on productive activities such as fishing, hunting and farming.	Requires explicit modelling of the 'dose-response' relationship between the resource or function being valued and some economic output. Application of the approach is most straightforward in the case of single use systems but becomes more complicated with multiple use systems. Problems may arise from multi-specification of the ecological-economic relationship or double counting.

Related good method Uses information about the relationship between a non-marketed good or service and a marketed product to infer value. The *barter exchange approach* relies on actual exchange of non-marketed goods. The *direct substitute approach* simply assumes that a marketed good can be substituted for a non-marketed good. The *indirect substitute approach* also relies on a substitute good, but if the latter is not exchanged in the market its value is inferred in terms of a change in economic output (i.e.,the direct substitute approach combined with the production function approach).	These approaches may provide a rough indicator of economic value, subject to data constraints and the degree of similarity or substitutability between related goods.	The barter exchange approach requires information on the *rate of exchange* between two goods. The direct substitute approach requires information on the degree of substitution between two goods. The indirect substitute approach requires information on the degree of substitution and on the contribution of the substitute good to economic output.

Constructed market techniques Measure of willingness to pay by directly eliciting consumer preferences. *Simulated market* (SM) constructs an experimental market in which money actually changes hands. *Contingent valuation method* (CVM) constructs a hypothetical market to elicit respondents' willingness to pay. *Contingent ranking* (CR) ranks and scores relative preferences for amenities in qualitative rather than monetary terms.	Directly estimates Hicksian welfare measure - provides best theoretical measure of willingness to pay. SM: controlled experimental setting permits close study of factors determining preferences. CVM: only method that can measure option and existence values and provide a true measure of total economic value. CR: generates value estimate for a range of products and services without having to elicit willingness to pay for each.	Practical limitations of constructed market techniques may detract from theoretical advantages, leading to poor estimates of true willingness to pay. SM: sophisticated design and implementation may limit application in developing countries. CVM: results sensitive to numerous sources of bias in survey design and implementation. CR: does not elicit willingness to pay directly, hence lacks theoretical advantages of other approaches.

Cost-based valuation		
Based on assumption that the cost of maintaining an environmental benefit is a reasonable estimate of its value. To estimate willingness to pay:	It is easier to measure the costs of producing benefits than the benefits themselves, when goods, services and benefits are non-marketed. Approaches are less data- and resource-intensive.	These second-best approaches assume that expenditure provides positive benefits and net benefits generated by expenditure match the original level of benefits. Even when these conditions are met, costs are usually not an accurate measure of benefits.
Indirect opportunity cost (IOC) method uses wages foregone by labour in production of non-marketed goods.	IOC: useful in evaluating subsistence benefits where harvesting and collecting time is a major input.	IOC: may underestimate benefits significantly if there is substantial producer or consumer surplus.
Restoration cost (RSC) method uses costs of restoring ecosystem goods or services.	RSC: potentially useful in valuing particular environmental functions.	RSC: diminishing returns and difficulty of restoring previous ecosystem conditions make application of RSC questionable.
Replacement cost (RPC) method uses cost of artificial substitutes for environmental goods or services.	RPC: useful in estimating indirect use benefits when ecological data are not available for estimating damage functions with first-best methods.	RPC: difficult to ensure that net benefits of the replacement do not exceed those of the original function. May overstate willingness to pay if only physical indicators of benefits are available.

Cost-based valuation (continued) *Relocation cost* (RLC) method uses costs of relocating threatened communities.	RLC: only useful in valuing environmental amenities in the face of mass dislocation such as a dam project and establishment of protected areas.	RLC: in practice, benefits provided by the new location are unlikely to match those of the original location.
Preventive expenditure (PE) approach uses the costs of preventing damage or degradation of environmental benefits.	PE: useful in estimating indirect use benefits with prevention technologies.	PE: mismatching the benefits of investment in prevention to the original level of benefits may lead to spurious estimates of willingness to pay.
Damage costs avoided (DC) approach relies on the assumption that damage estimates are a measure of value. It is not a cost-based approach as it relies on the use of valuation methods described above.	DC: first-best methods to estimate damage costs are useful for comparison with cost-based approaches, which implicitly assume damage is worth avoiding.	DC: data or resource limitations may rule out first-best valuation methods.

Source IIED (1994)